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THE

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FEEDING THE AFRICAN FARMER

In the past, the majority of agricultural field trials have been directed towards finding methods of raising the quantity and quality of important economic crops, and have involved the use of experimental methods (often of great complexity) for assessing the results obtained by selection, breeding, cultivation and different manurial programmes. In the United States and Canada, where one-crop farming has proved disastrous in many areas, attention has recently been directed towards another type of agricultural experiment, in which the farm is treated as an economic unit and where cash crops play a relatively minor part in a programme of mixed farming. Information obtained from this broader outlook, particularly on the problems of the small-holder, has greatly influenced agricultural practice in these countries, and it is interesting to note that similar investigations of tropical peasant farming have been in operation in East Africa for some years.

In an earlier number of this Journal (Vol. 7, 1941, p. 103) M. D. Graham described the aims and methods of an experiment in mixed farming which was started in 1937 by the Kenya Department of Agriculture at the Bukura Native Agricultural School, where some fifty African pupils are trained on thirteen demonstration farms ranging in size from $1\frac{1}{2}$ to 7 acres. In addition to the primary work of training, the opportunity has been taken to conduct a long-term experiment in intensive farming, in which many points are being investigated. Some of the major questions to which answers are being sought are:—

What is the maximum unit of land that can be worked by an average family in a reasonable daily working period?

What is the most suitable ratio of grass to arable, allowing for temporary leys to maintain fertility and for a sufficient number of stock to provide milk for the family and manure for the land?

How far can the indigenous pastures be improved by careful husbandry, and will this result on a cash profit from the sale of surplus milk and stock?

What size of mixed farm is required in order to produce an adequate diet for the family and yet show a profit at the end of the year?

The answers to these questions are of the greatest importance in planning the future of the African farmer, since they will tell us not only what a family can do, but also whether or not their efforts can produce a better standard of living.

In this issue, E. L. Bradford discussed the results of the Bukura experiments during the first eight years, and his article shows that very valuable results have been obtained. The average family is taken as consisting of $1\frac{2}{3}$ working units, giving 13 man-hours per day on an 8-hour day basis. On a 6-acre farm in Bukura there are four agricultural apprentices, each of whom spends only part of his time on the farm, their total being approximately $1\frac{2}{3}$ working units and therefore forming a "synthetic" family. It has been found that they can farm intensively a 6-acre holding with the aid of oxen, but to do this they must work more hours per week than is customary in the surrounding district. At the present rate of work in this area the native would require 12 acres, farmed on a more extensive system, in order to obtain the same total produce.

Bradford gives the food rations for the African pupils at Bukura the daily calorie total per head being 2,734, a balanced diet which is adequate for the type of work and far above the usual native diet. It is somewhat surprising that only 8.5 per cent of the food required (i.e. 232 calories) is not produced on the farm, which shows that a balanced diet is not beyond the reach of the farmer whose cash turn-over is small. The food required by four apprentices is roughly equal to that needed by an average family, and when this is subtracted from the total produced on a 6-acre farm it is found that a considerable surplus of food can be sold. This amounts to 37 per cent of the maize crop, 63 per cent of the roots, and 14 per cent of the legumes, representing an annual cash profit reckoned as Sh. 135 and sufficient to cover the small requirements of a family in clothes, tax, etc.

Encouraging as these results undoubtedly are, there are nevertheless one or two considerations which may limit their general application.

In the first place, Bukura is in cattle country at an altitude of 4,850 feet with a well-distributed rainfall of nearly 70 inches a year. Thus the findings of this investigation will not necessarily apply to lower altitudes or drier areas, although the method of conducting the experiment will be of value anywhere. Before a comprehensive answer to the question of the improvement of native agricultural practices can be obtained, many similar experiments would be necessary, covering a wide range of climates, and since it is several years before results can be expected, these should be started far in advance of development. Intensive short-term research on a large scale, which was so strikingly successful in solving some of the technical problems of the recent war, cannot be applied to rotational cultivation.

Secondly, an 8-hour day has been taken as the unit of work, but as is pointed out in the article, a marked change in the outlook of the average native is required before he will be prepared to work regularly eight hours a day. At present the African peasant works by fits and starts, and he does not find it easy to appreciate that regular planned work is required on a mixed farm. His fondness for attending every burial in the neighbourhood shows a decided over-belief in the saying "He that lacks time to mourn lacks time to mend", and it is clear that a long period may elapse before the Bukura standard of work becomes common. An 8-hour working day is not attractive to the African, and it must be noted that the Bukura experiments are carried out under European supervision.

In our plans for raising the native standard of living we must not forget that a large proportion of Africans may prefer to live in picturesque poverty than work six days a week, and to them the price of progress will seem prohibitive. On the other hand, much of this inherent lethargy is due to malnutrition. Before more work can be expected from an underfed peasant, he must have a better diet, but in order to get better food he must work harder; a vicious circle which will be hard to break. In the Annual Report of the Tanganyika Labour Department for 1944, reference is made to labourers recruited from the Gogo tribe, who "have shown a surprising aptitude for this form of work [rubber production] which has astonished all officers who have had contact with them, as members of this tribe had previously been considered to be unemployable." Much if not all, of this success was due to communal feeding, which ensured that the labourers were eating an adequate mixed diet which had been properly cooked. For the first few weeks after recruitment these men had great difficulty in finishing the full daily task, but the effects of better feeding showed up later and there was a marked change in their attitude towards work.

This method could not be applied to African farmers, but it does show that only a gradual increase in capacity for work can be expected. The present shortage of foodstuffs in East Africa is handicapping progress in improving the native diets, but the general principles are becoming clearer, and the set-back should be only temporary. Another point worthy of note is that there is at present little stimulus for the African to earn money, as the shortage of consumer goods gives him little scope for spending money. That situation is now improving rapidly, and there may be a marked change in the next few months.

The fear of want during the winter has made the smallholder of temperate climates one of the hardest working men in the world, and one wonders how the face of Africa would change if the same amount of skill, enterprise, and energy could be put into the land as has been done in many parts of Europe. This threat of starvation has played a large part in the development of intensive agriculture in Europe, since it provided a powerful stimulus for hard work. In East Africa the threat of the slave-raider forced some tribes into closely settled communities, and the cultivation systems which were developed under these circumstances show that the native can work out his own intensive practices without precept or example, but he does this only if it is the alternative to starvation or slavery. A. S. Stenhouse (this Journal, Vol. 10, 1944, p. 22) described farming methods in the Matengo Highlands in South Tanganyika, and showed that the fear of slavery had forced the people to cultivate intensively land which they would otherwise have left untouched. In recent years the threat of sleeping sickness has proved to be a useful stimulus to closer settlement under Government control, and the success which is being achieved in this mildly disciplined farming will undoubtedly influence future planning.

The surplus food produced on the Bukura 6-acre holding is of importance to the community as a whole as well as to the farmer himself. The dietary standard of employed labour is rising, and there is some doubt about the capacity of the land to produce the extra

food required. In this number, R. W. R. Miller draws attention to the need for careful consideration of this point, and he gives estimates of the acreage required to provide all employed labour in Tanganyika with rations on the Government standard. In his opinion the necessary food will be available only if every African peasant in Tanganyika devotes 10 per cent of his farming to the feeding of employed labour. His plea is that food must be stored from year to year in order that the good seasons may make up the deficiencies of the bad, but the question arises as to whether or not every African peasant can sell 10 per cent of his total produce over a number of years, and yet provide an adequate diet for his family. Plant-breeding could bring about a 10 per cent increase in yield, if the soil is sufficiently fertile to satisfy the increased demand for plant nutrients, and on that subject attention is called to an article by A. Glendon Hill in this number. He considers that plant-breeding must play a major part in post-war development. If the Bukura experiment can be taken as a guide, more intensive farming methods would ensure a substantial surplus which should find a ready market. The low prices for farm produce which prevailed prior to 1939 were due to under-consumption and bad distribution rather than to over-production, and if the standard of nutrition throughout the world is raised there should be no difficulty in marketing food crops.

We are frequently told in well-worn phrases that the interests of the native are paramount, that the land is being held in trust for the native, and that the African standard of living must be raised. At the moment, however, over-cultivation in many of the native farming areas, coupled with a series of abnormally dry years, is causing acute anxiety about the food position in East Africa. The immediate task, therefore, is to keep the African alive, and it is possible that this emergency may obscure the real issue, and that efforts may have to be directed to the production of food regardless of the cost in soil fertility. The long-term problem is the production of more food per acre, not merely the production of more food, but before we attempt any radical change in native agriculture practice we must find a better method by trial over a number of years. The application of theory to practice is dangerous unless it undergoes a long trial period in the field, and these fact-facing experiments at Bukura deserve replication in many other parts of Africa.

D.W.D.

NOTE ON THE VEGETATIVE PROPAGATION OF COFFEA ARABICA

Before the war peat moss was obtainable, and with the correct proportion of coarse sand gave a very suitable medium for the rooting of cuttings. During the war peat moss could no longer be obtained and coco-nut fibre did not prove to be quite as suitable. Since 1940 coconut fibre has also become increasingly difficult to buy at a reasonable price at inland places such as Moshi. In view of these circumstances a search was made on the higher levels of Mount Kilimanjaro for decomposed mosses resembling peat moss. Only shallow deposits were found and these proved unsuitable.

Attention was then drawn to the need for the cheap disposal of the hundreds of tons of coffee husks dumped outside the Coffee Curing Works in Moshi. Experiments were begun on the composting of this material and recommendations were made for its use as litter in calf pens, etc. Its possibilities as a constituent of a rooting medium for rooting cuttings were then considered.

It was tried out tentatively in one frame and showed promise. Fifteen frames were then prepared with a medium composed of two parts by volume of coffee husk and one part of coarse sand. Each frame was planted up with a different clone. A summary of the results, obtained by *pupil* propagators, is given below.

Date of first planting of cuttings: 30th January, 1946.

Number rooted at end of eighteenth week, 6th June, 1946: 923 or 40 per cent.

Cuttings still continue to root. The mortality in the frames was very low.

The average time to root cuttings of *Coffea arabica* at this station is eighteen weeks, and coffee husks have proved very suitable and are recommended for this purpose.

In view of Government's decision to replace by clonal material, over a period of years, all African-grown coffee on Kilimanjaro, some 12,000,000 trees, involving the use of many hundreds of propagation frames, this discovery is of considerable economic importance to the coffee industry.

24th June, 1946. S. M. GILBERT.

AFRICAN MIXED FARMING ECONOMICS AS APPLIED TO BUKURA, NYANZA PROVINCE, KENYA

By E. L. Bradford, Assistant Agricultural Officer, Kenya

(Received for publication on 8th May, 1946)

To dispose of essential data as quickly as possible particulars relative to this article are tabulated:—

Locality.—Bukura, North Kavirondo, Nyanza Province.

Altitude.—4,850 ft.

Climate.—Hot and humid, with high, drying winds in the dry season (December–February). Two crops a year (March/April and August/September).

Rainfall.—66.3 inches (average of 22 years).

Soil Types.—On the toplands the prevailing type is a shallow red top-soil, with little humus, overlaying ironstone (murrum) subsoil. It easily packs and, owing to the impervious subsoil, quickly dries out.

The lower slopes of the ridge are deeper and richer in texture, varying from black forest to red loams.

Plant Succession (Principal stages):—

(*a*) Pioneer. "Black Jack" (*Bidens pilosus*), "MacDonaldi" (*Galinzoga parviflora*), "Mexican Marigold" (*Tagetes minuata*), *Ageratum conyzoides*, *Eleusine indica*, *Digitaria* spp. (mostly couch grass types).

(*b*) Transitional. *Brachiaria*, *Digitaria* spp., *Wedelia*, *Cynodon* spp., *Setaria* spp., *Paspalum*.

(*c*) Dominant. *Eragrostis* spp. (one very similar to Meadow Grass but unpalatable), *Sporobolus fimbriatus*, *Hyparrhenia rufa*, *H. cymbaria*, *Cymbopogon*, *Panicum maximum*, *Sorghum arundinaceum*, *Themeda triandra*.

An earlier article by M. D. Graham [1] deals with native mixed farming detailing the work being carried out on thirteen demonstration mixed farms at Bukura, their layout, their aims and objects, and specific points on which it was hoped the trials would yield useful data. The present article can be considered a continuation.

The original demonstration mixed farms were laid out with a hypothetical ratio of pasture to arable of roughly 50–50. Thus, on a 6-acre farm this enables a smallholder to have three acres under crops and three acres of pasture or ley planted to selected grasses.

Three acres of Star and Kikuyu grass pasture are sufficient in this area of high rainfall to graze three adult beasts, one half-grown animal, and one or two calves all the year round. If hay and supplementary feed are grown for the dry period (January–February) six mature beasts can be maintained, i.e. two head of stock to the acre.

Natives visiting Bukura, however, often state that they have many more than five or six head of cattle and also much more than six acres of land, and ask what is to be done with the surplus. To clarify any doubts which tend to persist in the absence of visual demonstration, No. 18 mixed farm of 12 acres is being developed on the lines of a holding where, although crops are to be grown for the family's food as well as some cash crops, the main source of revenue will be stock and dairy produce. With this end in view the lay-out will be eventually:—

	Acres
Cultivation (already planted)	3
Temporary ley (already planted) ..	3
Timber plot (already planted) ..	$\frac{1}{4}$
House, vegetable garden and compound (prepared)	$\frac{3}{4}$
Permanent pasture (preparing) ..	5
Total:	12

The three acres of ley will be sufficient to rotate with the three acres of arable, and, being adjacent to the cultivation and having the night boma situated therein, where all crop residues and farm trash are laid, it will be sufficient also for the manuring of all the arable land once every three or four years. The five acres of permanent pasture, if natural pasture, should carry four or five additional stock (on current results already obtained here), or nine or ten head if planted to selected grasses, making in all ten or sixteen head respectively. This should allow of approximately three working oxen, seven cows, and five or six growing progeny. Of the seven cows, four should be in milk at any given period of the year, whilst bull calves would be fattened for the market. Thus a satisfactory increase of revenue should be derived from stock to

augment the cash crops. The three working oxen would not be sufficient for farm draught purposes; neither is allowance made for keeping a bull. A co-operative principle is developing hereabouts whereby peasants pool their resources—to purchase ploughs, or for sharing of oxen and a bull. Alternatively they hire them. It is also, I think, a policy of the Veterinary Department to disperse grade bulls throughout the Reserve for the improvement of local stock, and when this system is developed on a larger scale breeding of stock will be mostly from Government supplied sires.

The trials referred to in the previously mentioned article by Graham, which have been continued, are now tending to yield more definite results as regards:—

(1) The maximum unit of land that can economically be worked by an average family under intensive conditions.

(2) The minimum stock and arable required to produce an adequate diet for an average family.

(3) The optimum unit of land required to give a family a reasonable standard of living.

(4) The ratio of stock to arable.

(5) Improvement of pasture.

(6) Hedges.

(1) The Maximum Unit of Land that can be Economically Worked by an Average Family under Intensive Farming Conditions.

Emphasis is placed on *intensive farming* for there is no doubt that in the years to come more intensive conditions must prevail if land hunger amongst peasant farmers is to be reduced to a minimum. The present system of shifting cultivation, no manuring, and little whole-hearted attempt at, or interest in, soil conservation cannot go on indefinitely. From the African point of view it is the simplest method, and much greater acreages can be worked per family by such slip-shod *extensive* methods, but in this article the economic unit applies expressly to intensive farming.

The next point to consider is the average size of the family. In the absence of local statistics it will be safer to work on known figures of another tribe, and Humphrey's figure for the Akikuyu [2] is adopted for the purpose of this article, viz. 5.69. Of this number the man and his wife are adult workers, although the wife would not spend more than one-third of her time in the *shamba*, having some or all of the remaining 3.69 to look after, and the cooking, firewood, and water-carrying chores to perform; in fact a veritable "beast of burden by day and spouse by night". Of the 3.69 remainder of the family probably 2.69 would be too young to assist except perhaps by watering the stock, whilst the one unaccounted for may be old enough to assist, but also of school age; so at the most he or she could probably only assist for an hour or so in the late afternoon and at a week-end; say one-third of a day. This brings the family participation and assistance to one and two-thirds working units which, on the basis of an 8-hour day would give 13 work hours daily.

On the other hand the family might comprise a middle-aged man and his wife, and one or more of the children approaching, or arrived at, the adult stage. Alternatively, the family may comprise an adult dependant or relative, e.g. widow. In such cases the family would possess some two and two-thirds working units which, with an 8-hour day, gives 21 work-hours daily.

On Bukura there are four agricultural apprentices (constituting a "family") on a 6-acre mixed farm. Of this number, at any given period, one would be in class, one doing household and compound chores, one periodically on practical work outside the farm, e.g. rice, carpentry, etc. (average half time), and one working full-time on the holding. Therefore the average daily work on the holding is 1½ units, and the average working hours, including milking, 8¼ hours; giving 12¾ work-hours daily. This is the daily number of work-hours required to get through the routine work of a 6-acre mixed farm operated on intensive lines.

Comparing this basic work-hour requirement for a 6-acre farm with the work-hour potentialities of the above two hypothetical average-sized families it will be seen that *providing they work an 8-hour day* the families can successfully manage the same unit of land on the same intensive lines as at Bukura.

There is, however, a snag. Improvidence, *laissez faire* and indolence, combined with the general peasant tendency to enjoy life to the full, and visit every burial, beer drink, and market (to hear the latest news and scandal and to collect the money for the produce head-loaded by the wife) reduce the average working day to five hours. One seldom sees people around here working after noon.

One and two-thirds working units of five hours give only eight work-hours daily for the first hypothetical family and thirteen work-hours for the second. The contentions are, therefore, that:—

(*a*) Intensive farming for the present can only be carried out by the more industrious farmers, or those families with adult children or dependants.

(*b*) The remainder will have to modify their recreation somewhat, or there will have to be greater stimulus (such as acute land shortage) or social-welfare propaganda, before their energies can cope with intensive farming.

(*c*) As, under prevailing work-hours, the majority of families cannot operate a 6-acre mixed farm under intensive conditions, they will require more land to give the same yields; viz. 3 acres or more arable, 3 acres under 3- or 4-year fallow; and, as the pasture would be natural rather than planted to suitable grasses, 6 instead of 3 acres would be required for their stock. The total would be 12 acres extensively run as against 6 acres intensively.

(*d*) Over and above these acreages, both the industrious and the indolent could arrange the remainder of any land they might own as permanent natural pasture with rotational grazing.

(*e*) Considerable instruction by means of appropriate propaganda (such as welfare centres, wireless talks, films, vernacular publications, agricultural shows, and practical demonstration centres such as Bukura) will be required before even the industrious could be educated to improve their farming efficiency, and change over to better methods. Without comprehensive knowledge of improved methods much well-intentioned effort would be wasted. This aspect cannot be over-emphasized. Half the time the peasant farmer cannot grasp what we are driving at. Thoughtful, lucid propaganda, disseminated in a simple and interesting manner, would considerably simplify the work of the agricultural staff, and should be a pre-requisite of any anticipated campaign.

(2) THE MINIMUM STOCK AND ARABLE REQUIREMENTS TO PRODUCE AN ADEQUATE DIET FOR AN AVERAGE FAMILY.

A 6-acre mixed farm at Bukura produces annually on the average the crops given in Table I:—

TABLE I.

Crop	Fields or Contours	Agreage	Av. Yield per acre *Bags*	Total Yield *Bags*
Maize ..	3⅓	2	6	12
Sorghum and Wimbi ..	1	0·6	4	2·4
Cassava and Sweet Potatoes ..	1⅔	1	10-12	11
Soya, Peas, Beans, and Groundnuts	3⅓	1·8 to 2	2	3½-4
Hay	⅔	0·4	—	—
	10	5·8 to 6		

There are generally five contours (which constitute fields) to each farm, equivalent, planted twice yearly, to 10 contours, whilst the total of 5.8 to 6 acres as shown in Table I is likewise 3 acres of arable planted twice annually.

Sorghum is planted in the "long rains" and ratooned in the "short rains". Sweet potatoes are in the ground one year but a further plot is planted during the rains prior to uprooting of the old crop, so that the root crop is always available for consumption. Cassava remains in the ground two years but could be left longer. Hay is left in for two seasons. Small quantities of peas and beans are interplanted with maize during the "long rains" to maintain seed and give a small yield for consumption to tide the grower over until the main "short rains" plantings.

Maize is mostly planted in the "long rains". An average of one field or contour is, however, planted in the "short rains" to maintain seed and tide the grower till the main harvest. Gramivorous birds are periodically a menace following the "short rains" plantings and this maize crop and the ratooned sorghum suffer considerably on occasions. Furthermore, the soil is physically poor on many of the holdings and may contain from 10 per cent to 45 per cent murrum. Hence the conservative yield figures given above.

Details of rations for apprentices are as in Table II:—

TABLE II

Daily Ration	Annual requirements for 4 apprentices on 6-acre holding *Bags*	Acreage requirements to produce this quantity	Production surplus (*see* Table I) *Bags*
Maize meal 1 lb.	7½	1·25	4½
Millets ⅓ lb.	2⅓	0·6	nil
Roots ½ lb.	4	0·35	7
Legumes ⅓ to ½	2⅓ to 3½	1·1 to 1·75	1¾ to ½

Besides the crops listed in Table II, 1/16th acre of onions is planted as a cash crop (either planted separately or interplanted with newly planted cassave), and the house compound produces vegetables for home use and for sale. One narrow-base contour is planted to banans, the surplus bunches being allowed as a cash crop. Fruit trees are also planted in the compound to vary the diet.

Of the two milch cows to each holding one or the other should be in milk at any given period; this ensures apprentices a milk ration with a small surplus for sale. Some of the surplus cereals and legumes goes to supplement the feed of hand-reared calves and cows in milk.

Additional to the rations in Table II apprentices receive 1 lb. meat, ¼ lb. ghee, and salt, weekly. It will be seen later that the calorific value of the rations obtained solely from the holdings could be sufficient without these additional rations.

It is submitted that the food consumption of Bukura "families" of four adults is equivalent to the average Reserve family of 5.69 of varying ages (from the "muling and puking infant" to the "child creeping unwillingly to school").

As shown in Table III these rations (calculated on an annual basis) compare favourably with those quoted in the Humphrey Report, which were extracted from figures given by Dr. Harvey in the *East African Medical Journal*:—

TABLE III

Diet	Bukura Rations		Dr Harvey's ration for family 5·69
	4 adults per annum	Calorific value daily (per head)	
Maize meal	7½ *bags*	1440*	6 *bags*
Millet	2⅓ ,,	533	2 ,,
Beans Soya, groundnuts	— 2⅓-3½,,	— 111	½ ,, —
Potatoes Cassava, sweet potatoes	— 4 ,,	— 280	2 ,,
Milk	36½ gal	76	160 gal.
Ghee Vegetoline (*See also* soya and groundnuts)	— 52 lb.	— 117	91½ lb.
Meat	208 lb.	115	365 lb.
Green vegetables	365 lb.	32	276 ,,
Sugar	—	—	137 ,,
Tea	—	—	23 ,,
Fruit	seasonal	30	
Total Calories		2,734	
Deducting calories not produced on the farm (meat, oil)		232	
		2,502	

*White maize meal calory value is not known: yellow meal is 96, and white meal has therefore been estimated at 90.

From the foregoing it will be seen that a 6-acre mixed farm, even on the basis of the conservative yields given above, will produce enough food, and more than the minimum requirements, to supply the needs of a family of 5.69, together with a small surplus.

Cash Returns

It must be remembered firstly that apprentices are only in the process of learning agricultural science; they are therefore not adepts; they are permitted to make minor mistakes in order to learn from experience, e.g. late planting resulting in reduced yields, etc. Secondly apprentices are permitted certain cash crop items as perquisites, seldom admitted at their full value, and in consequence entered in their farm accounts at a minimum figure. Tables IV and V give profit and loss figures on pre-war values from the 6- and 5-acre holdings. Clothing has not been allowed for. Supplementary feeding costs are deducted in

these figures, also labour costs (maintenance, production and development), and personal expenditure. The natural increase of stock is considered in the light of a cash sale, and the surplus stock re-allocated to prevent over-stocking and over-grazing.

TABLE IV

Holding No.	Acreage	1941	1944	1945
2	6	Cr. 106/12	Cr. 159/10*	Cr. 166/04*
3	6	Cr. 128/82	Cr. 68/05†	Dr. 22/18†
5	6	—	Cr. 163/40†	Cr. 164/61†
6	6	—	Cr. 172/85	Cr. 21/-
7	6	—	Cr. 192/91	Cr. 184/48
8	6	—	Cr. 55/88	Cr. 122/80
11	6	—	Cr. 182/10	Cr. 170/17
Average profit per 6-acre holding ..		.. ..	142/04	104/07

*Feeding teacher and 2 children besides 4 apprentices.
†Feeding teacher trainee, wife and children besides 4 apprentices.

TABLE V

Holding No.	Acreage	1941	1944	1945
12	5	—	Cr. 35/05	Cr. 454/2
13	5	—	Cr. 167/95	Cr. 149/65
14	5	—	Cr. 162/80	Cr. 3/73
15	6	—	Cr. 139/84	Cr. 88/31
16	5	—	Cr. 84/89	Cr. 172/25
Average profit per 5-acre holding ..		.. ..	118/11	91/84

The 5-acre holdings have only three apprentices working them, so, for the purpose of obtaining accurate data to enable us to arrive at the minimum requirements to produce an adequate diet for an average family, the cost of feeding another apprentice will have to be deducted from the average profit of the farm. From actual figures obtained here, based on the ration given in Table II, the annual cost of feeding one adult apprentice is Sh. 85. Deducting this figure from the average profits of a 5-acre holding leaves a profit of Sh. 33/11 for 1944 or Sh. 6/84 for 1945.

Alternatively, Table VI presents the yields obtained from a 5-acre farm for comparison with the annual requirements of four adults. Fields or contours are as in Table I but they are proportionately smaller.

TABLE VI

Crop	Acreage	Average yield per acre *Bags*	Total yield *Bags*	Annual requirements of 4 apprentices *Bags*
Maize	1·7	6	10·2	7½
Sorghum and Wimb	·5	4½	2	2½
Roots	·8	10-12	8¾	4
Legumes	1·5 to 1·7	2	3-3¼	2½ to 3½
Hay	·3			
	4·8 to 5			

From this Table it will be seen that a slight additional ration of maize would be required to compensate for the shortfall in other cereals. The legumes are practically sufficient—with no margin of safety.

As regards milk and minimum stock requirements for such a family; a 5-acre holding having 2½ acres of ley planted to good grasses can carry at the most, with supplementary feeding, two cows, one ox, and two current-year calves, one of which at least would have to be sold the following year to make room for subsequent natural increase. Of the two cows one should be in milk at any given period. The average milk yield of local cows, over and above their calves' requirements, is not more than two bottles a day or 125 gallons per annum. This, nevertheless, would be ample on the basis of Bukura rations for adults, but not sufficient for a growing family on the basis of Dr. Harvey's ration of 160 gallons. It must be remembered, however, that the youngest child would probably be breast-fed.

Again, if the calves are hand-reared, as at Bukura, the calves' milk would be gradually reduced and a supplementary feed given; whilst from the fifth month onwards all the milk would go to the family. Furthermore, for a few months of the year both cows should be in milk at the same time.

It is therefore considered that a 5-acre mixed farm worked intensively is, under most Nyanza conditions, the minimum acreage which could supply the average-sized family with an adequate diet. There would be little margin of safety however.

(3) THE OPTIMUM ACREAGE REQUIRED TO SUPPLY A FAMILY WITH A REASONABLE STANDARD OF LIVING.

The first consideration is: "What constitutes a reasonable standard of living" (*a*) at the present time, and (*b*) for the near future when further enlightenment and progress will enhance the African's desire for a better and more comfortable standard of living? Figures based on present standards will be obsolete in ten years' time.

There is no reason to suppose that peasant farmers will not attain to standards of living on a par with those of the white-collar brigade. To train either section of the community to the stage of efficiency would take quite as long for the agriculturalist as for the clerk, whilst the former copes with greater risks of reduced income in unfavourable seasons. One basic standard for all grades has therefore been taken as the aim.

Present wage scales in Kenya can probably be said to range from Sh. 11 plus food and housing to Sh. 70 per month, depending on training, ability and efficiency. Africans in both the higher and the lower scales mostly have further hidden assets, such as their own land in the Reserve, with their wives working it. This might possibly increase their earnings by Sh. 100 annually, for they would consume food to the value of Sh. 85 if they were at home.

Social welfare experts are tentatively working on an annual income of Sh. 400 which allows for improved standards of living in the near future. This figure is therefore taken as the basis.

A mixed farm of seven acres has been satisfactorily managed by four apprentices here and has shown an average profit over the last two years of Sh. 219 (computations being on pre-war prices). It is quite probable that they could have managed eight acres, but very improbable that they could have managed more without sacrificing intensive efficiency. In the writer's opinion an 8-acre mixed farm (having four acres arable and four acres ley) is the maximum a family can operate. Any land owned beyond this figure would have to be put down to permanent pasture, the stock increased accordingly, and the balance of their cash requirements would have to come from dairy products. If a high-priced crop such as coffee is the main cash crop then the position would be altered, but not necessarily in the best interests of the land.

Five acres produced an average profit of Sh. 105, and, when these figures were amended to allow for a full-sized family, the profit was reduced to Sh. 33/11 (for 1944) or Sh. 6/84 (for 1945); in other words it merely produced enough food for the average family with little cash to spare.

Six acres fed the family from five acres and produced a surplus averaging Sh. 135 mostly from the sixth acre.

Seven acres fed the family from five acres and the remaining two acres produced the bulk of the profit averaging Sh. 219.

On this premise:—

Eight acres feed the family from five acres, leaving three acres for profit, which, on the ratio above, should produce at least Sh. 84 more than the seven-acre farm, bringing the total to Sh. 303. Three bottles of milk daily at 10 cents per bottle from the additional stock on the permanent grazing would be required to bring the farmer's profits to the basic Sh. 400. (The sale of natural increase from the additional stock on the permanent pasture—*see* below—would allow a very comfortable margin of safety.)

The stock on the 7-acre farm consisted of 2 cows, 2 two-year-old bulls, 2 yearling heifers, 2 calves, and 1 ox. On the maximum unit of land required to produce Sh. 400 cash, the farmer should be self-contained as regards oxen. He will therefore need 6 oxen, 4 cows, and progeny up to two years old (ready for sale), say 3 two-year-olds, 4 yearlings, and 3 calves, totalling 14 grazing beasts and 3 calves. The 4-acre ley will carry eight head, and six acres of natural pasture would be required for the balance; giving a total of 14 acres. If, however, the permanent pasture is planted to suitable grasses three acres would suffice, making the total acreage of the farm 11.

(4) AND (5) THE RATIO OF STOCK TO ARABLE, TOGETHER WITH THE IMPROVEMENT OF INDIGENOUS PASTURES.

With the present system of night *bomas* (kraals) in which all farm trash is laid, five head of stock can manure three acres every four years and maintain fertility. These figures are again borne out on the Seed Farm where the manure from 20 oxen penned at night suffices three acres annually, or 12 acres every four years, the balance of the arable being inter-planted to Sword beans and turned in as

green manure. It must be emphasized that this ratio only obtains in cases where, firstly, ample trash is laid in the night *boma* and the *boma* moved periodically (the moving of the *boma* systematically manures and maintains the fertility of the ley pending its rotation with the arable); secondly, proper terracing is practised to eliminate undue erosion; and thirdly, correct rotations are followed.

As previously stated five head of stock can be comfortably pastured on three acres of planted pasture. The three acres of arable is sufficiently manured by these five head of stock to maintain its fertility. The ratio is, therefore, five beasts to three acres of arable.

It may be argued that three beasts should give seven tons of manure per annum if penned at night, and that two tons per acre per annum are quite sufficient to maintain fertility on good soils.[3] This does not apply to Bukura where the physical and mechanical condition of the soil is poor and where heavy concretions of murrum are to be found. To maintain fertility on such soils, therefore, it is necessary to increase the rate of application of humus.

Pasture Improvement

Whilst it is generally confirmed that controlled grazing of natural pastures will improve them, the word "eventually" must of necessity be added to the sentence. It is a slow process. So much depends on the initial fertility of the soil, and its texture. Paddocks prepared here in 1940/41 have still not increased their carrying capacity, although better grass types are at last appearing. On the other hand a concerted effort at planting suitable grasses in these same paddocks would have increased the carrying capacity in 18 to 24 months—and time is money.

The system is accepted that where intensive farming is practised there should be sufficient ley to rotate with the arable. The writer submits that the principle could be taken further; that, having completed the rotation, it should be extended to that portion of the permanent pasture which is suitable for cropping, thereby planting as much of the acreage as possible to suitable grasses and increasing the carrying capacity over a larger area.

Planting Methods

The interplanting of grasses between the rows of the final crop is proving fairly successful here providing the land is kept well weeded, and the grasses (Star and Kikuyu) planted after the first weeding—which must be thorough. It takes from four to six months for the rhizomes to extend to the base of the maize crop (if planted in rows 4 ft. apart), by which time the crop is off. A second weeding is given when the crop is mature, and, as the rains persist here until later, a third weeding is given after the crop is off, by which time the grasses are generally sufficiently established to hold their own.

The success obtained with planting grasses on old arable depends upon the residual fertility and the crumb texture of the soil. (Incidentally the arable retains its fertility longer here if not overworked by constant cultivation and harrowing. With normal crops one, or at the most, two weedings are given and the weeds then left to grow. By that time the crop is maturing and the weed growth will not adversely affect yield, but will leave a good cover to plough under in due course.) On played-out soil Cynodon plantings become very wiry, with little foilage, and have poor palatability.

Old arable is ploughed in the dry season and when the first weeds grow following the grass rains, is either ploughed a second time or well harrowed—depending on weed growth. Star and Kikuyu grasses can then be planted but will require at least one weeding during the rains. Newly planted leys on old arable will still contain a heavy admixture of weeds at the end of the rains, despite twice ploughing, and weeding. These weeds, if cut at the right time (when they have flowered but before the seed sets) will produce a moderately palatable hay crop. Such cutting prevents the pioneer grasses from overshading and smothering the more decumbent planted grasses.

The ploughing of virgin sod and planting grass directly is stated by Graham in his aforementioned article to be altogether satisfactory providing the desired grasses are treated for a short period as a field crop. Excellent pastures may be esablished within a period of three months when a mixture of Kikuyu and Cynodon is used, or pure Cynodon from cuttings. He goes on to state that magnificent pasture has been established under this method although, in practice, it was found better from the native point of view to take a cash crop off the land first and plant grasses on removal of the crop. The writer thinks it possible that the grasses could be interplanted with this

cash crop, as outlined above, although it would then take longer than three months for the grasses to form a complete cover.

Ploughing up Old Pastures

It is often stated that pastures planted to Cynodons and/or Kikuyu grass are difficult to plough up, and that, when planted to crops, the grasses persist. It has been found possible at Bukura to eradicate these satisfactorily by first putting in a heavy concentration of cattle for at least a month before ploughing, to graze the grass short. The first ploughing, in December, at the end of the rains, when the soil is drying out, can then get well into the turf. The soil and the grass roots are then left to dry out for a month or more when a second ploughing is given just before the "grass rains"; followed by either a harrowing or a third ploughing in the dry spell between the "grass rains" and the main "long rains". In heavy-rainfall areas vegetative growth is so rank that it is impossible to plough out pastures at any time of the year other than the dry season December/February.

Pasture Maintenance

Paddocks must be adequately stocked to prevent selective grazing and the undue elimination of the finer and more palatable types of grasses.

Staples has stated [4] that pastures rested during the second half of the rains give the best results in carrying capacity; in protection of the soil; in control of weed growth; and in encouraging the growth of perennial Star Grass which is the outstanding species from both pasture and soil conservation viewpoints. This method has been tried in the rotational grazing paddocks this year and appears satisfactory. It apparently enables the rhizomatous grasses to spread and anchor themselves sufficiently to withstand damage by subsequent grazing.

Once a season the paddocks are gone over with a hoe, and young bushes, rank tufty grasses, and noxious weeds are removed.

Leys seeded to such species as Rhodes grass (*Chloris gayana*) and Teff (*Brachiaria brizantha*) have not been a success. Weed growth is so rank that it establishes itself long before the seeded grasses, which tend to become choked. *Eleusine indica* and *Wedelia* sp. are the chief offenders. For this reason Rhodes and Teff are late-planted as a hay crop after two crops of weeds have been ploughed and harrowed under. Even so they cannot last longer than two season. The first season gives a stand in the ratio of 70 per cent hay to 30 per cent weeds, whilst in the second season the hay percentage is less than 35, and curing is difficult. *Bromus marginalis* is being tried this year.

Haystacks require to be built on staddles and the top of the stack well thatched; and as this method is not likely to appeal to the African, part of the milking sheds were partitioned off, forming open frame-work hay-sheds.

Other supplementary fodders grown are Uganda Napier Grass (*Pennisetum purpureum*—not to be confused with the coarse Kenya or Sudan type of Napier), and sweet potato foliage. Napier is planted on contours and, besides forming an excellent washstop, forms an indispensible and palatable additional feed for the dry season, as well as other periods, four to five cuttings being obtained annually. Sweet potato foliage planted in the standard rotation is used principally for the calves.

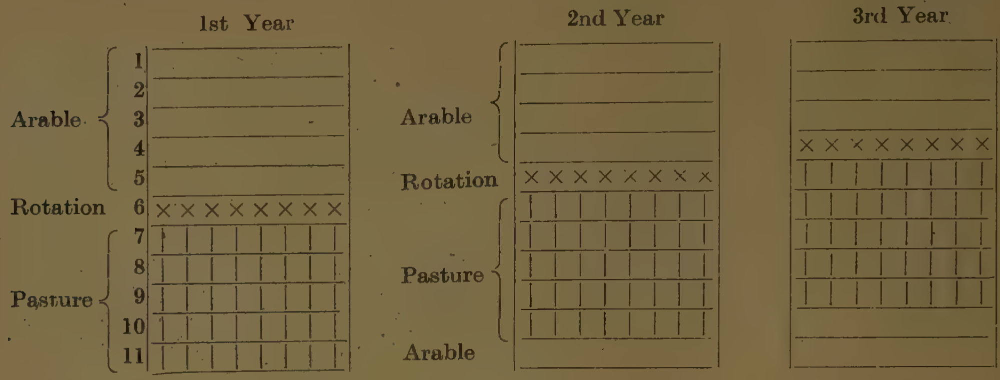
Rotation of Pasture and Arable

This problem becomes bigger the smaller the holding. On a 5- or 6-acre farm, with the leys the same size as the arable, if one-fifth of either is in course of rotation, either the cropping acreage will be reduced for a year or the stock will be short of grazing. One or the other is going short.

On three smaller holdings of 1.5, 1.8 and 2.5 acres respectively the problem is insoluble and in the course of arable-pasture rotation the stock have had to be grazed off the holdings and tethered on adjacent farm roads—which fortunately are put down to Star/Kikuyu sward and tend to become overgrown.

The only solution appears to be that both the grazing and the cropping land should bear the burden equally (one-tenth each). With this idea in view certain holdings have been divided into 11 contours or fields. If the vertical intervals between the contours exceed 3 ft. (which is seldom the case here on five or six acres) an intermediate contour is lined out to prevent erosion.

Of the 11 fields or contours five are under crops, five under pasture, and one under rotation, and each year the rotation is moved to the next contour thus:—



On the rotational contour, if rhizomatous grasses are interplanted with the last crop, the land should only be unproductive for one year at the most.

If it is a new farm in the making and the whole of the pasture area is too large to plough and plant to suitable grasses in one year, the rotational area only can be ploughed and planted; and so on, until the whole pasture is planted to a good grass sward.

As the rotation moves up, the wire fence between the ley and the arable is moved one season or one year later, thus excluding stock from the new pasture until it is well established.

(6) Paddock Hedges

The fencing of stock is another very important economic factor to be considered in African agriculture. The tendency is to cut down every available tree for this and other purposes. For a 6-acre mixed farm fenced on all boundaries, with two fences dividing the paddocks for rotational grazing purposes, approximately 980 yards would require fencing posts. If mixed farming on a general scale should come into vogue the Reserve would be completely denuded of trees in no time. It is advocated, therefore, that the only wire fences should be those separating the pasture from the arable and two fences dividing the pasture into paddocks for rotational grazing, for these would have to be moved periodically in the arable/pasture rotation.

All permanent demarcations should be hedges. Trials are, therefore, in progress with a considerable number of hedge plants. Different types of hedges are planted on the different demonstration farms, some having as many as six varieties on trial.

A suitable hedge must possess the following characteristics:—

(*a*) Easy to establish.

(*b*) Quick growing.

(*c*) Easy to trim.

(*d*) Stock-proof.

Brief descriptions of some on trial are given.

Hedge Plants

Duranta plumieri.—Quick growing; slightly thorny; handsome, but wilts during the dry weather. The slightest gap in the hedge is sufficient for the stock to break through as the thorns, although up to one inch in length, appear to be brittle on the cow's hide. Easily kept in trim by a bush knife. Strikes well from cuttings, but, a month or so after planting, the cuttings tend to die off (an 80 per cent strike will be reduced to 30 per cent, so cuttings should be planted four or five inches apart). Poor germination from seed, even when boiled or lightly roasted.

Kei Apple.—Essential to plant in nursery and leave for 12 months (younger seedlings are too easily damaged). Slow growing, takes three to four years from transplanting to become fully established. Handsome, strong thorns, stock-proof, easily trimmed.

Euphorbia sp.—Planted from cuttings. Attains a height of 4 to 5 ft. in two years. Fragile fence and dangerous to cattle on account of the caustic properties of the sap, causing blindness in cattle. If left to grow 5 to 6 ft. would probably be stock-proof as cattle appear to fear its caustic properties. Easy, though rather dangerous to trim, but, having little side-growth, only periodical topping is required.

Giant *Solanum* sp. (Lirovo, Luluhiya).—Seeded in banana pots, the seed first boiled or lightly roasted. Used extensively by Wameru as a hedge and considered by them capable of keeping out elephants when allowed to grow to 15 ft. When the side branches are intertwined it makes a good fence. Stock-proof; growth 5 to 6 ft. in 12 months. Not a handsome hedge.

Cassia grandifolia.—Planted in banana pots as it does not transplant well. Quick germination; quick growth, 4 ft. in 12 months. Is transplanted 2 ft. apart. If well pruned in the first year becomes bushy. Easily trimmed; no thorns. Hedge tends to form gaps. Handsome foliage and flowers. Doubtfully stock-proof.

Mauritius Thorn (*Caesalpinia sepiaria*).—Seeded at stake, the seed first boiled or roasted. Germination good. Slow growth the first year but rapid thereafter. Must be kept well trimmed otherwise it gets out of hand. Constant trimming, however, causes it to die out after seven years or so. Very thorny, tricky to trim. Very stock-proof.

Dovyalis sp. (Sinduli).—Strikes more readily from cuttings than Duranta. Thick third and fourth year wood will strike, thus expediting its establishment. Has edible fruit, leaves reddish tinge, fairly handsome, stools well. Promising but too early to state whether stock-proof or whether easily trimmed.

"Lutsoi" (a local shrub).—Long thorns, deep green foliage, resembles Kei Apple but appears to be quicker growing. Planted from seedlings; does not strike from cuttings. Transplanting losses negligible.

Tecoma capensis.—Strikes from cuttings and easily layers; thorny; pretty flowers. Too early to comment.

Permanent Fencing Posts and Shade

Wild Fig.—Strikes easily, good shade, useful for dividing paddocks.

Markhamia platycalyx (also, probably, *M. hildebrandtii*).—Transplanted from nursery. Transplants easily. Good shade, not too heavy. Useful for dividing paddocks. Coppices well. Very useful timber for yokes, roofing poles, etc.

In all cases it is advisable to keep the hedges cultivated annually until they are mature; it speeds up growth. They should be trimmed after the first year's growth to enhance stooling and branching.

In the early stages of growth cattle tend to use the cultivated hedge strip as a path, thereby damaging the plants. It is advisable, therefore, where possible to plant hedges ahead of requirements, so that they are at least 12 to 18 months old before the stock are let loose.

Of the varieties mentioned above Kei Apple is probably first choice to date as an effective and handsome permanent hedge. It is, however, much too slow a grower. Second choice is Giant *Solanum* for its effectiveness and quick-growing habits, but it is not a pleasing hedge.

A trial is being made this year to plant a row each of Kei Apple and Giant *Solanum* (rows 2 ft. apart), the object being to establish the hedge quickly with the Giant *Solanum* whilst the Kei Apple is slowly establishing itself. The *Solanum* will eventually be cut out.

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[2] Humphrey, N., and others.—"The Kikuyu Lands", Government Printer, Nairobi, 1945.

[3] Faulkner, O. T., and Mackie, J. R.—*West African Agriculture*, p. 70.

[4] Staples, R.—"Bush Control and Deferred Grazing as Measures to Improve Pastures", *East African Agric. Journ.*, Vol. 10, 1945, p. 217.

I believe that quite as many people are ill because they are unhappy as are unhappy because they are ill.

W. Langdon-Brown in *Thus we are men.*

I hope I have succeeded in giving the progressive farmer food for thought; for to do that, I have always held, is the chief function of a practically minded scientist.

Sir George Stapledon.

CONVERSION OF VELD GRAZING INTO LEY PASTURES IN THE KENYA HIGHLANDS

By J. M. Nightingale, Sasumua Estate, Kinangop, and H. T. Lloyd, Assistant Agricultural Officer, Kenya

General Outline

We have written this article in the hope that it will draw attention to the possibilities of ley farming, incorporating a grass and crop folding system, in the higher rainfall areas of East Africa. We would stress that the results achieved to date on Susumua Estate have been purely in the nature of an experiment which is continuing.

The whole principle of the experiment is that maximum use must be made of the limited land available, and to this end all cultivable land had to be broken up and the fertility of the poorer soils increased, by methods described later in this article, in order to allow them to support improved pastures. All fodder crops and ley grasses are grazed on a folding system with the aid of an electric fence, and by the methods employed not only are the poorer soils being enriched, but also the milk yields have been increased enormously.

Although the herd is a high grade Friesland one, yields in the past have been at a low level, owing chiefly to the poor milk yielding qualities of the natural grasses. Nevertheless, the figures (*see* Table 2) of these yields are valuable for the comparisons which they afford, and it is safe to say that these increases have been due solely to grazing on better pastures and crops rather than to any improved breeding, since the majority of the cows milked in 1943 were still in the herd in 1945.

Sasumua Estate

The farm which has been used for the experiment is 500 acres in extent at an altitude of 8,500 feet above sea level. The average annual rainfall over the last seven years is 38.12 inches. The good distribution is shown in Table I, which gives the monthly rainfall for the past three years.

Of the 500 acres, 171 acres are under pyrethrum, wheat, orchards, vegetables, tree plantations, buildings, etc., thus leaving 329 acres to carry 209 head of stock, comprising 97 head mature cattle, 68 heifers and 44 calves. In 1943 another 300 acres of grazing had to be rented to enable the 200 odd head of stock to be carried, but in 1945 the 209 head were successfully carried on the 329 acres.

Much of the 329 acres is poorish land, typical of the Kinangop. It varies from "Manyatta" soil which needs much working before it is suitable for the growing of ley grasses, to a poor pinkish-grey clay loam which needs much building up before it will grow even oats when fertilized.

TABLE I

Monthly Rainfall at Sasumua Estate, Kinangop.

	1943	1944	1945
January ..	0·94	1·04	2·06
Febuary ..	1·06	0·23	2·55
March ..	1·81	4·50	1·98
April ..	5·70	8·04	2·36
May ..	10·53	1·91	8·09
June ..	2·02	2·44	5·02
July ..	0·04	3·48	2·42
August ..	2·14	3·43	7·24
September	1·70	7·33	0·47
October ..	0·75	3·99	1·24
November..	2·43	4·34	5·25
December	1·08	1·47	Nil.

Lay-out and Crops Used

The sizes of the paddocks vary, but most of them are from 15 to 20 acres with two gates. For ease of ploughing a big field is preferable, but for folding a small one is easier, and a balance must be struck between these two factors: the narrower the paddock the easier for the folding.

Ley grasses have so far been limited to *Bromus marginatus*. Other possible grasses are Italian and perennial ryegrasses, *Phalaris tuberosa and Beckeropsis* sp. Before any of these ley grasses are sown, the land has to be built up. This has been done by rotationally using the poorest land in small areas for night paddocks, which has continued for up to two years. The land is then ploughed and a crop of oats planted with a heavy dressing of phosphatic fertilizer. The resultant green crop is then rotationally grazed by folding; two or three re-growths may be obtained from the one seeding. Sunflowers are used in rotation to clean land into which undesirable indigenous grasses may have spread; they are folded off, once only, in the lush stage when the first flower buds are showing, and afterwards the land is reploughed. It is most important that the maximum use be made of these "pioneer" fodder crops in the building up of poor land. By the above method some of the poorest land on Sasumua is now capable of growing good crops of grass and the

SASUMUA'S MILKING HERD—AVERAGE YIELDS PER COW PER DAY
52 Weeks

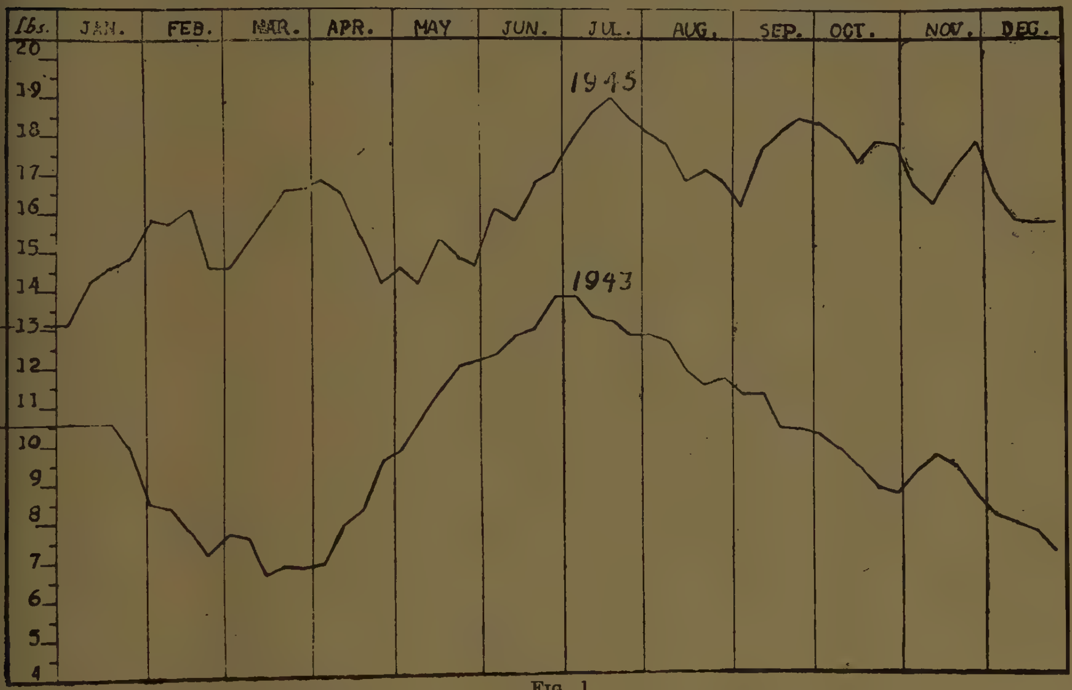

FIG. 1

whole experiment, of course, centres on the conversion of poor veld land to a pasture with a high carrying capacity.

Discussion and Records

Careful records have been kept of the whole experiment and they are expressed in the accompanying tabulated and graphic forms to give an indication of the results so far achieved. As folding commenced half way through 1944, the figures for that year are not thought to be of much value in this article and therefore those for 1943 and 1945 only are given. A graph showing the average yields per cow per day in 1943 and 1945 is given in Fig. 1. In 1943 the herd was on ordinary rough grazing with the usual feeding of concentrates. In addition, the herd was fed as much green feed as they could consume during milking time in the form of oats, cabbages, mangolds, etc.

This was all very expensive and extremely tedious, involving much transport and wastage of labour. In 1945 the day feeding was on growing crops of oats, sunflowers and bromus, which were all folded. At night the cattle were paddocked on the poorest land which was being prepared for its initial ploughing. The concentrate ration was reduced and no green crops were fed at milking time.

TABLE II

Monthly Milk Sales—Sasumua Estate.

	1943 gal.	1945 gal.
January	498	2,048
Febuary	385	2,041
March	376	2,172
April	432	1,980
May	626	1,604
June	784	1,795
July	1,018	2,335
August	1,155	2,687
September	1,022	2,897
October	954	3,241
November	894	3,101
December	761	3,349
Total	8,905	29,250

Table II shows the actual milk sales off the farm during 1943 and 1945. In 1943 there was at times barely sufficient production to allow enough skim milk for calves and pigs, whereas in 1945 it was possible to sell all the increase in milk resulting from the new methods being employed.

The total number of milking cows in December, 1943 was 89 and this figure had risen to 113 by December, 1945. No cows were bought during this time, but some were sold.

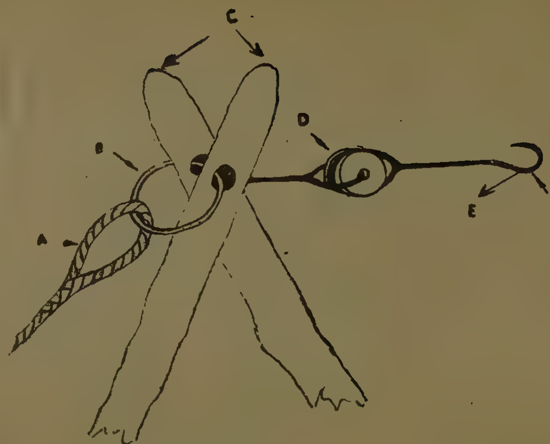

FIG. 2
A. Rope
B. Ring
C. Bipod legs
D. Insulator
E. Thick Wire Hook

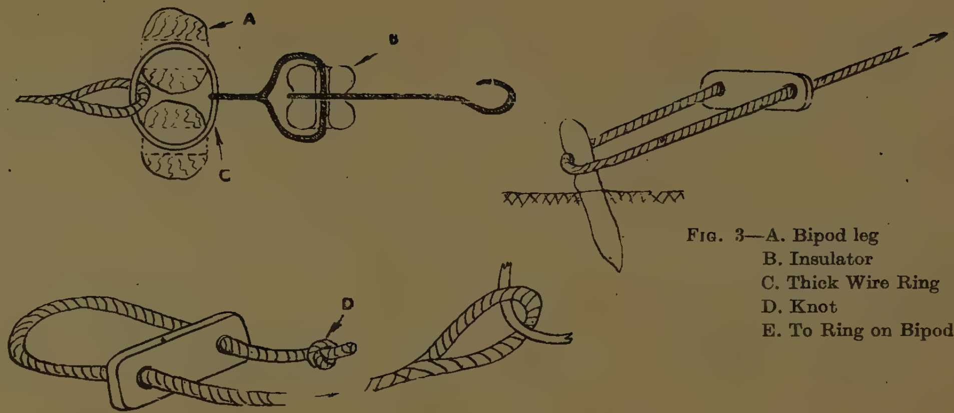

FIG. 3—A. Bipod leg
B. Insulator
C. Thick Wire Ring
D. Knot
E. To Ring on Bipod

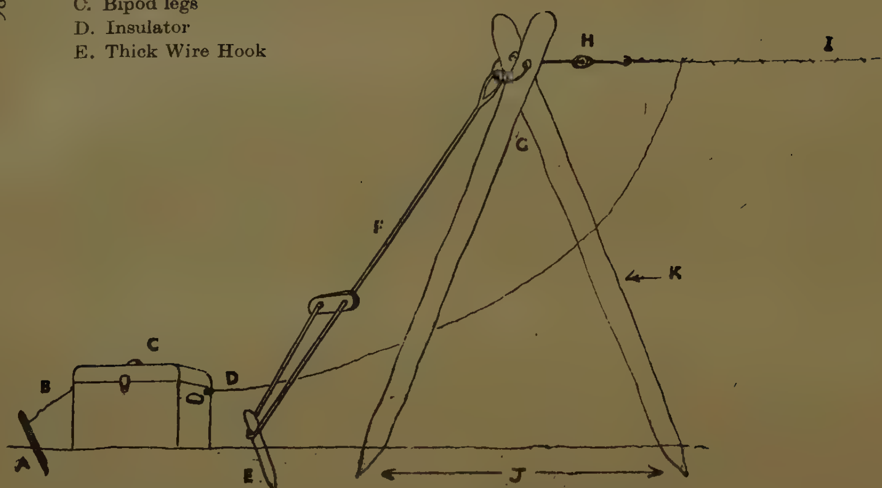

FIG 5
A. Ground Iron Peg
B. Electric fence unit ground wire
C. Electric fence unit
D. Electric current wire lead to fence
E. Tent peg
F. Bipod straining rope
G. Wooden bipod
H. Insulator and hook
I. Barbed wire
J. Slightly pushed into ground
K. 3" diam. hard wood 5′ 6″ point to ring

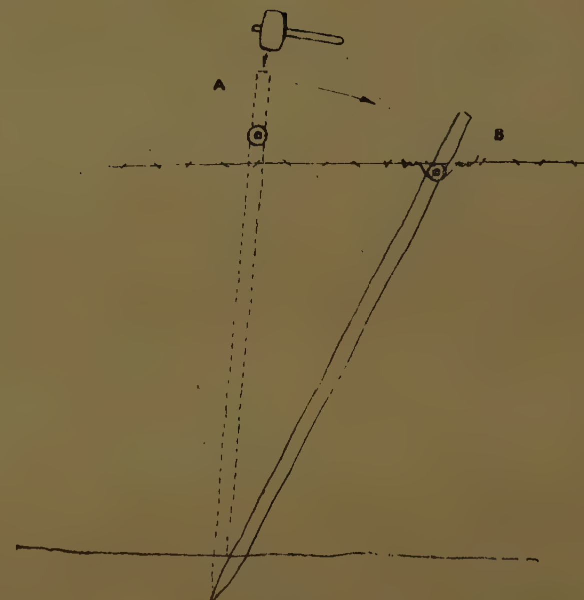

FIG 6
Knock the dropper in as in position *A*, then push it down in position *B* and fasten insulator to the folding wire

FIG 4
A. Insulator
B. Hard wood dropper

LARGE FIELD

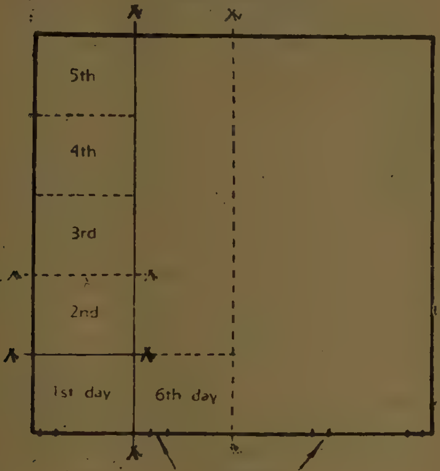

FIG 7. GATES

SMALL FIELD

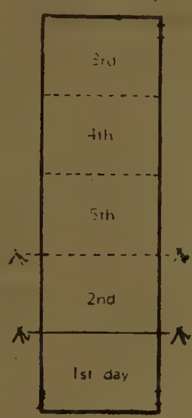

FIG. 8

IRREGULAR FIELD

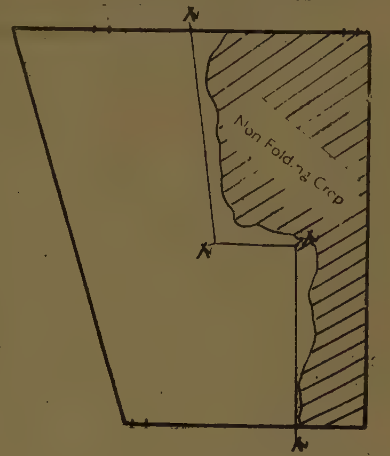

FIG. 9

Costs

The complete cost of folding in 1945 was £301. This figure comprises labour, seed, fertilizer, tractor and cultivation expenses and electric fencing. In 1943 the cost of growing crops, transporting them and the extra labour required was £120. For the increased cost of £191 it is of interest to note that the actual sales of milk off the farm represented an increase of 20,345 gallons in one year.

Electric Fence

The movable fence, which is simple, quick and easy to shift consists of the following:—

(*a*) One strand of barbed wire.

(*b*) Wooden bipods and droppers (for details *see* Fig. 2).

(*c*) An electric fencing unit with insulators.

Figs. 7, 8 and 9 show the various suggested methods of arranging the fence on different types of fields.

The method of erection is as follows:—

(1) Place the wire on the ground in the desired position.

(2) Hook a bipod on each end and adjust the two legs until the wire is at the desired height, at the same time pushing them firmly into the ground.

(3) Strain the wire by pulling the apex of the bipod and tightening the rope over the peg.

(4) Attach droppers with soft baling wire approximately 10 yards apart, as shown in Fig. 6.

The droppers are first driven into the ground with three or four blows with a mallet, and then pulled down in line with the fence to the desired height, when the baling wire is then wound on to the fence.

FINAL HINTS

Some of the lessons learned in nearly two years of folding will probably be of some value to others. Some of the more important are given below:—

(1) It is advisable to keep the cows on the previous day's folding for a few hours before moving them on to the new area to be folded.

(2) Ley pastures should be folded. This ensures controlled grazing and prevents the cattle from rushing all over a fresh pasture and picking out the tit-bits with resulting hoven and also wastage of feed.

(3) It has been found necessary to have a reliable herder always with the herd. He is equipped with a mouth-stick, kerol, trocar and knife. If taken in time the kerol and the mouth-stick are nearly always sufficient. It is sometimes better to use a knife instead of a trocar when wads of grass are found to block the cannula. Neat kerol is poured into and around the wound. Of course, knife and trocar are only used as a last resort.

(4) Kerol is added daily to the salt lick as a preventative against hoven. This is added at the rate of one bottle of neat kerol to a debbi of salt, and 4 lb. of the treated salt is then added to each sack of approximately 180 lb. of concentrate fed.

(5) It is of the utmost importance towards the end of the year to plant "pioneer" crops with every available rain. This was done successfully at the end of 1944, but in 1945 the short rains stopped early and the result of this can clearly be seen in the 1946 milk yields.

(6) As soon as possible "pioneer" crops should be replaced by grass leys. Milk yields are always considerably higher on ley grasses than on any grown crop, at least on Sasumua. *Bromus marginatus* gives higher milk yields than on any grown crop, at least on Sasumua. In this connexion it is also interesting to note that fertilized oats produce more milk than unfertilized.

MECHANIZED FARMING

By H. O. C. Hunter, Mbosi, Mbeya, Tanganyika Territory

(*Received for publication on 28th May, 1946*)

With the advent of a more intensive type of mixed farming on the ley system it may be of interest to review the newer kinds of farm machinery. Ley farming entails the treatment of every cultivable acre on the farm, whereby the fertility of the farm as a whole is raised in each cycle of the rotation. It can be adapted to the various East African conditions, but not successfully with ox power and the unskilled labour available.

Modern British farm machinery is efficient and of robust construction. It has been evolved to suit the rather critical requirements of the British farmer, who, by his sound methods of long and short duration leys enabled Britain to produce 75 per cent of her food supplies during the last war, and by this production made her one of the most highly mechanized farming countries in the world.

All new implements are now made for power operation, either to be towed by a tractor, self-propelled or power take-off.

The following description of implements and machines has been taken from *The Farm Implement and Machinery Review*, published monthly at 9, The Broadway, Woodford Green, Essex, at Sh. 10 per year. This review describes all new machines as they are produced. Unfortunately, very few prices are quoted but when they are, these prices, which are the cost in England, are given here in brackets. Another publication giving the results of tests and various information on agricultural machinery, including American, is *The Agricultural Engineering Record*, published for the National Institute of Agricultural Engineering by H.M. Stationery Office, price 4/4d. per year. These two journals will keep the farmer informed and up to date. A recent report by the National Farmers' Union of Great Britain, although not literally applicable to East Africa, gives an idea of the relative life of various machines.

Tracklaying tractors, 8 years; four-wheel type tractors, 7.6 years; tractor ploughs, 11.9 year; disc harrows, 9.9 years; grain drills, 10.7 years; mowing machines, 14.6 years; sweeps, 10.4 years; binders, 11.7 years; combine harvesters, 7.7 years; balers, 14.4 years.

In addition to the tractors already in use in East Africa the following are of interest:—

"Field Marshal", Diesel, four wheels, described as pulling a 3-4 furrow plough on an average of one gallon of fuel per acre.

"Fowler" crawler type, 54 h.p.; 40 h.p., 24 h.p,. 12 h.p., all diesel-engined. Messrs. Fowler made heavy tanks during the war and expect to fit a new type of track which will reduce cost and servicing; the 24 h.p. and 12 h.p. are made with power take-off for rotary hoes and may interest coffee planters.

"Fordson Major" (£275). The Ford Motor Company are making their own implements for this tractor, having already produced a 3-furrow plough.

The "Ferguson", with hydraulic lift, is made by Standard Motors, Coventry.

In the low h.p. class there are:—"Bristol", 9 h.p., four wheels; "Kendal", 7 h.p., four wheels (£100); "Ransome", 7 h.p., tracklayer.

A tractor plough usually needs a heavier implement to work the land down afterwards. Of heavy tandem disc-harrows there are several makes, one for use with a Fordson-type tractor is priced at £65.

The self-cleaning tooth harrow is a useful implement when one considers the reluctance of the native to lift up the harrow to clean it. There are two kinds, one a fitting for existing harrows, the other a part of the harrow.

The flexible harrow, which can be joined together for tractor work, or divided for use with oxen, is the only implement which will roll up couch after the self-cleaning tooth-harrow, and is the best for harrowing-in grass seeds.

When considering grain drills it would be wise to make sure they will drill-in grass seeds, as drilled seeds are more satisfactory, especially in dry areas, but America has specialized in drills for the lighter, chaffy varieties of grass seed that will not go through a grain drill.

For those who broadcast artificial manures there is a range of distributors from 4 ft. widths, drawn by hand, to 20 ft. widths for tractors, one make being an attachment for a lorry (£52/10.). I say for those who broadcast manures, as there is still some indecision as to the best method of applying them. This indecision does not appear to be caused by the fearsome suggestions put forward by dilettante exponents of the humus theory.

The success of this system of farming depends upon the building-up of fertility by the natural application of animal residues to the ley without the cost of carting, but for seasonal routine application of farmyard manure several makes of spreaders have been on the market for many years which I know from experience will spread varying amounts per acre in an efficient manner, but they are not geared for oxen. Four makes of "muck loaders" are described in the *Agricultural Engineering Record*.

One of the most interesting machines so far produced is the "McConnel-Bomford" harvester. It has been invented by a farmer in Hampshire with the idea of producing a machine to do the work of a combine and to be sold at the price of a binder. It is described as a revolutionary harvester, an unorthodox machine weighing 6 cwt., worked by a small auxiliary engine and drawn by the tractor. The grain is bagged as with a combine, and it is claimed that the loss due to spillage is less than a bushel per acre. Forty of these harvesters are being made this year by Messrs. Wild and Co., Ltd., 50, Pall Mall, S.W.1, for use in different parts of England.

Haymaking with oxen and unskilled labour is a depressing affair, as the various manual processes in handling hay require considerable skill. The tractor mower, side delivery rake (£40) and the one-man pick-up baler cuts out all manual labour. These balers, which from their description appear to be rather expensive machines, pick up hay or straw from the windrow, bale it and drop the bale on the ground. A less expensive outfit would be the mower, side delivery rake and hay sweep (£35). There is no reason why hay sweeps should not be made in East Africa; they can be used for sweeping hay, straw or silage crops, where so much time and labour is lost in loading carts. A baler is one of the greatest assets on any farm; it facilitates rationing, saves waste, and enables a bigger load to be carted in a shorter time.

Having milked 60 cows night and morning with milking machines and the help of one other man I believe in them. They can be made to produce clean milk with a very low bacterial count, whereas the native, usually a wet-handed milker, can usually be relied upon to produce extremely dirty milk. A heifer trained to milking machines will not stand in the paddock for the herd boy to milk her. For those who really like milking there is the American DeCarli system by which three men milk 200 cows night and morning. Then there are the self-recording and releasing types, which deliver the milk direct to the dairy without it being in contact with the bacteria-laden atmosphere of the byre, and also the portable bucket types. A milking machine, if properly used, will not milk a cow quicker than a good man, but a man with machines can milk several cows at once. A survey, made by the Agricultural Economics Research Institute, of 134 farms in England whose income was mainly derived from milk, shows the average production to be 5,000 gallons per man employed, with highly efficient farms producing 10,000-14,000 gallons per man. Mechanical milking has a greater influence than yield on output per man.

Any electrically minded farmer or orchardist may be interested in a West Australian experiment in which an electric fence unit was adapted as a bird-scarer. The principle of construction is to run a live wire and an earth wire parallel and close together so that a bird can make contact between the two. The limit of wiring is the capacity of the unit.

One other machine which may be of use to anyone interested in grain storage is the Marconi battery-type moisture-meter, operated by a 1.5 volt low-tension or 45 volt high-tension battery. The machine is portable and gives on a dial the moisture content of grain.

When considering the economics of mechanized farming, I suggest that it is not only the more immediate advantages that must be put against depreciation, but also the accumulating assets that this method of farming brings with it, two obvious ones being increasing fertility and the direct effect ley farming will have on the control of erosion.

DURABILITY OF SOME EAST AFRICAN TIMBERS

By L. T. Wigg, M.A., Silvicultural Division, Forest Department, Tanganyika Territory

(*Received for publication on 10th March, 1946*)

This article has been written with the object of introducing a provisional list summarizing information on the reputed durability of some of our local timbers. Durability is defined as ability to resist destructive agencies, such as termites, wood-borers, fungi, the teredo or shipworm, acids, mechanical wear, etc.[5]

Bases of Information

Wherever locally available information allows of it, the results of trials in the improvement of durability by impregnation with preservatives have been included in the notes on the timbers. For nearly one half of the 285 species mentioned there is some information from the interim results of a trial laid down at Morogoro in two series (1936 and 1937) by D. K. S. Grant, then Conservator of Forests, Tanganyika. Further details of this test will be given below. The other main sources of information are in references appended, the chief of which are Eggeling's book [2], the Kenya Catalogue [1] and unpublished bulletins of the Kenya Forest Department [14] [15]. Duff's trials in Northern Rhodesia are of interest as regards the timbers of the Dry Forest.[4]

Reliability of Information

Having written this much on the bases of the information, I must explain why the word "provisional" has been used for the list and the word "reputed" for the durability of the timbers.

As most users of timber realize, there are many factors which may influence the service performance of a timber placed in exposed situations. Wood is not a homogeneous material and its properties vary from species to species, from tree to tree in the same species, and from part to part in the same tree. This last variation is very marked as between sapwood (almost always perishable) and heartwood (generally more durable). The history of the timber in rates of growth, forest conversion, seasoning, etc., will influence durability. In the sites where the timber is used the actual prevalence of wood-destroying insects may vary and the conditions for the growth of decay-causing fungi may be favourable or unfavourable. I think it is the failure to note these attendant circumstances which is the main cause of occasional conflicts of view as regards durability (Nos. 2, 59, 176, 244 and 253). As an example of this the Sukuma living to the south of Lake Victoria state that *Acacia fischeri* is a borer-proof pole useful in hut construction, but they may fail to add that in order to make it so they water-season it. On parts of Kilimanjaro, the Elgon Olive (No. 244), elsewhere considered very durable, is regarded as perishable. The local use of this tree in small round timber, derived from quick growing pollard shoots with a large proportion of sapwood, is probably the reason for condemning it. Again, it is easy to record information, while travelling, that a certain timber is regarded as termite-proof and at the same time fail to note that wood-destroying termites are in fact scarce in the area. A third cause of variation is the method of forest conversion. The quicker drying that follows on the immediate removal of the bark will sometimes improve the resistance of a timber to borers which would otherwise soon reduce it to a powder. (*Harungana madagascariensis* as a rafter is an example.)

Even trials of timber of the "graveyard" type lead to conflicting results. I know of no published results of an East African trial which include the statistics of the standard type required by the modern statistician. He requires an assurance that the observed differences are significant effects of treatments with a definite measure of the probability of the answers being due to the treatments and not, for instance, to the chance position of single pieces having by a favourable stance evaded attack. Investigators of the termite resistance of timbers consider now that these tests should be brought into the laboratory, where approximately equal numbers of a known species of termite can be offered equal opportunities of eating the test pieces [8]. This has been done by Findlay [5] with four important species of decay-causing fungi for a series of timbers. Some of these are East African species and his notes on them are mentioned in the list.

One or two of these timbers (printed with quotation marks) are of doubtful identity or cover more than one species, and there are one or two synonyms mentioned as separate timbers. I am obliged to P. J. Greenway, Botanist at Amani, for indicating these, for bringing some names up to date, for correcting

the botanical nomenclature in some items and for making other suggestions. No East African territory yet has a published territorial flora. Belgians, Frenchmen, Portuguese, Germans, Italians and British have all been collecting the same plants and sending them to be described and named (and often named differently) at their own national herbaria, one of which, incidentally, has been burned to the ground, with a consequent loss of original types. Uganda and Kenya have descriptive lists (stage 2) and Tanganyika has a check list (stage 1) as milestones on the way to comprehensive floras, but systematic botany generally in East Africa has been understaffed. It is also only in the last decade before the recent war that an acceptable method of clasifying timbers (pieces of wood) has been worked out at Oxford, Yale and Princes Risborough. From this has been developed a punch card index system which allows of rapid elimination in the identification of an unknown timber. Army engineers were using the method in the New Guinea campaign. Tanganyika timbers are now being classified in this way.

Explanatory Notes on the List

The use of systematic botanical names (if it needs an excuse) is unavoidable. There are few English equivalents and these are likely to lead to confusion. The native names vary from tribe to tribe. These native names are, however (if used with caution), extremely useful and they will lead in the vast majority of cases to the trees in the forest, if well authenticated names of the local tribe and guide are used. For Uganda and Kenya the books already mentioned have comprehensive lists and descriptions, and for Tanganyika the check list has very full lists of native names against the systematic names. This latter is soon to be augmented by a descriptive list.

Those to whom the use of timber is important should have their timbers vouched for by botanical specimens, together with samples of the wood from the same tree. Any information as regards the service performance of well-identified local timbers will be welcome.

The species of the list are given below in alphabetical order with the notes of the authorities indicated by the following abbreviations: D. (Duff [4]), E. (Eggeling [2]), F. (Findlay [5]), Fu (Fuller [6]), K.C. (Battiscombe [1]), K. (Kirkpatrick [10]), K.B.9 (Wimbush [14]), K.B.15 (Wimbush [15]), S. (Sangster [12]), Sk. (Skerl [13]). The Conservator of Forests, Salisbury, supplied notes on Southern Rhodesian mining timbers. Unacknowledged information is mainly from the records of the Forest Department, Tanganyika.

The figures in the columns show the number of months elapsing before a specimen was heavily attacked by termites (deep penetration and honey-combing) in the Morogoro trial, laid down by D. K. S. Grant. About half of the timbers were laid down six months in advance of the other half, which explains why some have lasted 91 + and others 97 + months. The plus sign indicates continued resistance. The query marks show estimates. These were necessary owing to the long lapse between examinations that occurred in the war. They were based on the condition of the pieces at the last examination. The description "heavily attacked" is not so exact as a volumetric measurement, but it is perhaps more stringent than the estimates of other investigators who appear also to have made these ocularly.

Although these test pieces were not properly replicated and randomized there is a general prevalence of voracious termites* in the trial ground. Scarcely any untreated piece in the test escaped at least a reconnaissance attack by termites (superficial skinning in spots).

The treated pieces were impregnated by the open-tank hot and cold process with the substance shown at the heads of columns (sodium arsenite, creosote and corrosive sublimate). These results are valuable in my opinion as a pilot trial for natural resistance and to indicate improved resistance by impregnation, particularly with creosote, which is available as a by-product of gas-producer power-plants in several parts of these territories.

Selections Suggested for Various Regions

For users of timbers in exposed positions (mines, railways and farmers), in the great *Brachystegia* forests which cover highly mineralized areas in the Rhodesias, the Congo and Tanganyika, the improvement of *Isoberlinia globiflora* with creosote is worth further investigation. This tree is extremely common over tens of thousands of square miles of this type. In extensive areas above 4,000 feet, *Isoberlinia paniculata* is similarly important. Other timbers growing in this type of vegetation which may be suitable (either for their natural resistance or with improvement) for

* W. V. Harris has identified, from a collection evenly distributed over the trial ground, workers of *Microtermes* sp., probably *M. parvus* Hav. and one specimen probably *Termes badius* Hav.

various applications in exacting conditions are *Acacia fischeri, A. goetzei, A. nigrescens, A. rovumae, Afrormosia angolensis, Afzelia quanzensis, Albizzia amara, A. anthelmintica, A. antunesiana, A. brachycalyx, Amblygonocarpus obtusangulus, Baikiaea plurijuga, Brachystegia spiciformis. Berchemia discolor, Boscia fischeri, B. salicifolia, Burkea africana, Cassia abbreviata, Combretum binderianum, C. imberbe, C. zeyheri, Crossopteryx febrifuga, Dalbergia ochracea, Dialiopsis africana, Entandrophragma bussei, E. caudatum, Erythrophleum africanum, E. guineense, Fagara merkeri, Faurea saligna, Hymenocardia acida, Lonchocarpus eriocalyx, Mimusops densiflora, Piptadenia hildebrandtii, "Pterocarpus* sp. *nov.", Sterculia quinqueloba, Swartzia madagascariensis, Tamarindicus indica, Terminalia sericea* and *Ziziphus mucronata.*

For those who have easier access to rain forests, river fringes or high-grass—low-tree savanas, the following are quoted:—*Acokanthera longiflora, Adina microcephala, Albizzia zygia, Allanblackia stuhlmannii, Baikiaea eminii, Baphia kirkii, Bersama paullinoides, Brachylaena hutchinsii, Bridelia micrantha, Calodendron capense, Catha edulis, Chlorophora excelsa, Chrysophyllum* sp., *Combretum schumannii, Conopharyngia holstii, Cordia holstii, Cordyla africana, Croton* sp., *Dombeya mastersii, Ekebergia ruppeliana, Ficus* sp., *Hagenia anthelmintica, Juniperus procera, Khaya nyassica, Lasiodiscus mildbraedii, Lecaniodiscus ?fraxinifolia, Maesopsis eminii, Markhamia platycalyx, Millettia oblata, Mimusops cuneifolia, Ocotea usambarensis, Olea chrysophylla, Parinari excelsa, Podocarpus gracilior, P. usambarensis, Pteleopsis myrtifolia, Pterocarpus zimmermannii, Pygeum africanum, Rauvolfia inebrians, Rawsonia usambarensis, Spirostachys africana, Steganthus welwitschii, Stereospermum kunthianum, Syzygium guineense, Teclea glomerata, Terminalia spinosa, Turraea fischeri* and *Warburgia stuhlmannii.*

Those to whom the riverine and coast mangrove formations are accessible may find applications for *Bruguiera gymnorrhyza, Ceriops candolleana, Heritiera littoralis and Rhizophora mucronata.*

Timbers Durable in Water

(*a*) *Resistant in fresh water.*—For native sailing craft on Lake Victoria the following have been used: *Afzelia quanzensis, Albizzia zygia?* or another *Albizzia, Chlorophora excelsa, Morus lactea* and *Pterocarpus angloensis.* Of these *Morus lactea* is reported to have given exceptional service (?15 years) as dock piles put in at Nungu pier by the Germans before 1914 to exploit the gold in the Bismarck Reef (S.W. Lake Victoria). Attention is called also to *Erythrophleum guineense, Juniperus procera, Mitragyna stipulosa* and *Phoenix reclinata.*

(*b*) *Resistant in salt water.*—Teak has the reputation of being one of the best shipbuilding timbers. For timber which is to be used in sea water, natural resistance to the teredo or shipworm adds greatly to its value, though this resistance can be improved by treatment. The teredo is a mollusc which bores through minute entrances into timber submerged in the sea, making galleries which increase in size with the growth of the animal. The following local timbers are suggested as worth investigation as resisting this pest: *Afzelia quanzensis, Chlorophora excelsa, Diospyros mespiliformis?, Erythrophleum guineense, Pterocarpus angolensis, Steganthus welwitschii, Terminalia prunoides, T. spinosa* and *Fagara* sp. near *F. macrophylla.*

I am indebted to Skerl [13] of the Land Department, Tanganyika, and to the Dar es Salaam Yacht Club for the substance of the following information:—

The teredo does not attack timber in the upper levels, "the sunshine zone" of the sea even at night. Boat timbers will be preserved by frequent drying and by waterproof painting. Woods which absorb water most easily are worst damaged. By planing off the surface of test pieces, which had been exposed in the sea, it was shown that the shipworm took about six weeks to penetrate into a distance of ¼ in., by which time its gallery was 1/20 in. diameter. After ten weeks the dimensions were respectively 1 in. and ¼ in. Drying periodically at some period of less than a month should reduce the effects of infestation. The damage was first examined for the number of borings per unit area. It was then realized that a volumetric measurement of damage was more important and that this itself appeared to vary with the toughness of the timber. On this criterion the timbers tested came out in the following order of excellence. The borings per unit area are given in brackets:—

1. Teak (0.0).
2. *Chlorophora* (1.0).
3. *Pterocarpus angolensis* (7.5).
4. Oak (4.0).
5. *Steganthus welwitschii* (1.5).
6. *Muna* (?) (3.5).
7. Spruce (5.0).

8. *Mkule* (?) (7.5).
9. Californian Redwood (10.0).
10. Deal (13.5).

Before leaving this subject further mention should be made of *Terminalia spinosa,* which I have seen growing on the Tanga coast, in the Wami and Ruvu alluvials in Tanganyika and I believe, on the southern slopes of the Marsabit Plateau, Northern Frontier District, Kenya.* This is a favourite keel-log for native ship-building at the coast, owing to its great toughness and strength and probably therefore because of its resistance to the teredo.

Timbers for Regeneration by Native Authorities

It would prolong this article unduly to make suggestions for the raising of naturally durable timber for native domestic use, but two timbers might be mentioned:—The first is *Spirostachys africana.* A house-post of this timber is reported as outlasting five reconstructions of native huts; almost an heirloom. At lower elevations on the drier edges of the flood-plain alluvials and at the bases of hills it is to be found in places in almost pure, though somewhat open, stands with a plentiful regeneration which seems to be establishing itself in spite of fire. The timber is also a substitute sandalwood. The second timber useful for the same two purposes is *Brachylaena hutchinsii* (Muhugu). This tree also shows natural regeneration in fair quantity, but it is very slow growing, at least in girth. This may be outweighed by its phenomenal durability. In the area north-west of Tanga timbering in the stockades constructed of this timber in the Masai wars is said to be still in place (?50 years durability).

Conclusion

Emphasis should again be laid on the provisional nature of this list. It is hoped that it will soon be superseded by another one which excludes the errors of this and adds a great amount of new information. A glaring omission is the failure to include information which local mycologists could supply.

I hope that nothing that has been written in this article will raise undue optimism about the natural resistance of any timber. Users of large quantities should consider from the first whether it would not prove cheaper over a term of years to impregnate their timber. Creosote and the new salt mixtures which are water-soluble but which undergo alteration which fixes the preservative substance in the cell walls so that it cannot be leached out, should be used if possible. An example of the latter type is chromel, a non-proprietary mixture elaborated at the Forests Products Laboratory, Princes Risborough. This impregnation is particularly applicable to timber used in the round because the sapwood, though generally very perishable, is usually also very amenable to preservative treatment, often when the heartwood is not particularly amenable. Some of the naturally durable species are too valuable or unsuitable in other ways (e.g. in their dimensions) for all exposed work. Users of large quantities will find non-resistant timbers generally easiest to impregnate. They are then usually more dependable than untreated wood of reputed natural durability. They are often available in larger quantities. Such users will be doing the forest economy of these territories, as well as themselves, a service by the closer utilization that can be applied if preservatives are used.

I wish to thank the authorities quoted for a great part of the information given here.

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* As *T. spinosa* has not been collected on the coast further north than Mombasa the Marsabit *Terminalia* may be some other species—P.J.G.

REPUTED AND TESTED DURABILITY, EAST AFRICAN TIMBERS (PROVISIONAL LIST)

Systematic Name	Morogoro Test Pieces			
	Un-treated	Sod. arsenite	Creo-sote	Merc. chloride
	Months before heavy attack			
1. *Acacia albida* Del. Prone to termites and borers (E.)				
2. *Acacia benthamii* Rochebr. Immune to termite attack (Fu)	?4	37	37	37
3. *Acacia campylacantha* Hochst. Less liable to termite and borers than most Acacias (E.) Intact with arsenic salts for 4-5 years (D.)	16	16	37+	37+
4. *Acacia eggelingii* Bak. f. Reputed durable (E.)				
5. *Acacia fischeri* Harms Water-seasoned hut poles, Sukuma.	37	?72	?72	?97
6. *Acacia goetzei* Harms	97+	97+	97+	97+
7. *Acacia hebecladoides* Harms (Unseasoned piece?)	4	13	97+	37
8. *Acacia lahai* Steud. and Hochst. Durable. (K.C.)				
9. *Acacia nefasia* Schweinf.	1	10	97+	37
10. *Acacia nigrescens* Oliv. Durable underground. (S. Rhod.) Tanganyika military sleepers. Immune to termites (Fu.) Very durable hut-pole.				
11. *Acacia rovumae* Oliv.? Very durable. Termite-proof pole (Usukuma)	97	38+	97	97
12. *Acacia seyal* Del. var. *fistula* Oliv. Susceptible insect attack (E.)				
13. *Acacia sieberiana* DC. Liable to borers (E.)				
14. *Acacia spirocarpa* Hochst.	2	8	97+	14
15. *Acacia usambarensis* Taub.	?84	?84	97+	97+
16. *Acokanthera longiflora* Stapf. Lasting probably more than five years in the ground (K.B. 9)				
17. *Acokanthera venenata* G. Don.	37	97+	97+	97+
18. *Adina microcephala* Hiern. Termite-proof pole. In wet mica mines mod. good condition after 21 years.	16	37	97+	?72
19. *Afrormosia angolensis* Harms. Tang. military sleepers. Untreated heartwood unaffected by termites in 11 years (D.). Dead heart fire-resistant.				
20. *Afzelia africana* Smith. Extremely durable (E.)				
21. *Afzelia quanzensis* Welw. Durable in salt water and in ground (K.C.) More than 10 years (K.B. 9) Tanganyika military sleepers. Good for 5 years in ground (D.)	40	40	43+	91+
22. *Agauria salicifolia* Hook f. ex Oliv.	½	10	43	14
23. *Albizzia amara* Boiv. Nyam. Mpogoro.	97+	97+	37	?84
24. *Albizzia anthelmintica* Brongn.	?84	?84	?84	97
25. *Albizzia antunesiana* Harms. Tanganyika military sleepers. Untreated heartwood unattacked in 11 years (D.)	97+	?84+	97+	97+
26. *Albizzia brachycalyx* Oliv. Untreated. Heartwood intact 66 months (S.)	97+	97+	97+	97+
27. *Albizzia coriaria* Welw.				
28. *Albizzia grandibracteata* Taub. 2-4 years in ground (K.B. 9)				
29. *Albizzia gummifera* C.A. Sm. Less than one year in ground and	26	43	91+	91+
about one year underground (K.B. 15.)	½	8	91+	12
30. *Albizzia versicolor* Welw.	26	26	91+	?85
31. *Albizzia zygia* Macbride. Fairly durable not termite-proof. Moderately susceptible to Bostrychids (K.)	37	37	97	37
32. *Allanblackia stuhlmanii* Engl. Termite-proof (Uluguru) Tanganyika military sleepers.				
33. *Allophyllus abyssinicus* Radlk. 2-4 years in ground (K.B. 9)				
34. *Amblygonocarpus obstusangulus* Harms. Untreated heartwood intact after 11 years (D.)				
35. *Aningeria altissima* Aub. and Pellegr. Untreated heartwood destroyed in 15 months (S.)				
36. *Anthoceista nobilis* G. Don. Perishable (E)				
37. *Antiaris usambarensis* Engl. Perishable (E.)	½	14	?91+	43
38. *Aphania senegalensis* Radlk. Durable if not exposed to weather (E.)				
39. *Apodytes dimidiata* E. Mey. Liable to borer attack (E.) 2-4 years in ground (K.B. 9)				
40. *Baikiaea eminii* Taub. Perishable (E.)	1	8	97+	14
41. *Baikiaea minor* Oliv. (?Synonymons with 40.) Very highly susceptible to bostrychids (K.)				
42. *Baikiaea plurijuga* Harms. Heartwood unaffected after 11 years (D.)				
43. *Balanites aegyptiaca* Del. Durable and insect-resistant (Wet piece?)	½	7	43	24
44. *Baphia kirkii* Bak.	91+	91+	91+	91+
45. *Bauhinia thonningii* Schumach. Perishable (E.)				
46. *Berchemia discolor* Hemsl.	97+	97+	97+	97+
47. *Bersama abyssinica* Fresen. 2-4 years in ground (K.B. 9)				

REPUTED AND TESTED DURABILITY, EAST AFRICAN TIMBERS (PROVISIONAL LIST)—*Contd.*

Systematic Name	Morogoro Test Pieces			
	Un-treated	Sod. arsenite	Creo-sote	Merc. chloride
	Months before heavy attack			
48. *Bersama paullinoides* Bak.	½	?43	91+	12
49. *Bersama* sp.	½	12	91	12
50. *Borassus flabellifer* L. Very resistant to termites and fungi (E.)				
51. *Boscia fischeri* Pax.	1	10	97+	37
52. *Boscia salicifolia* Oliv.	2	10	97	37
53. *Bosqueia phoberos* Baill. One year in ground, 1-2 years underground (K.B. 15)				
54. *Brachylaena hutchinsii* Hutch. Extremely resistant to insects and fungi (E.) More than 10 years in the ground (K.B. 9) ? 50 years Tanga. (Specimens broken and lost).	97+	?37+	?37+	?37+
55. *Brachystegia longifolia* Benth. Treated with arsenic salts lasted nearly 6 years (D.)				
56. *Brachystegia microphylla* Harms. Tanganyika military sleepers. May be good for 5 years in ground (D.)				
57. *Brachystegia spiciformis* Benth. May be good for 5 years in ground (D.) Tanganyika and Kenya military sleepers—				
As *B. edulis*. 2-4 years in ground (K.B. 9)	37	37+	37+	37+
As *B. itolensis*.	14	37	37	37
As *B. randii*, durable in wet situations and durable if treated in mines (S. Rhodesia				
58. *Brachystegia* spp. Generally 2-3 years in the ground untreated (D.)				
B. utilis 4 years with arsenious oxide (D.)				
59. *Bridelia micrantha* Baill. Probably over 5 years in ground and 5-10 years underground (K.B. 15). Exceptionally durable in ground and water and termite resistant (E.) Very generally accepted termite-resistant hut-pole.	1	37	97	16
60. *Bruguiera gymnorrhyza* Lam. Not particularly durable, Malaya. Tanganyika military sleepers. Immune to Bostrychids (K.)	8	97+	97+	?84
61. *Burkea africana* Hook. For mining purposes equal to any timber known. (S. Rhodesia.) Reputed fire resistant (D.) Durable (E.)	10	37	97+	37
62. *Calodendrum capense* Thunb. 2-4 years in ground (K.B. 9)				
63. *Canarium schweinfurthii* Engl. Liable to borers.	½	16	91	14
64. *Canthium schimperianum* A. Rich. 2-4 years in ground (K.B.9)				
65. *Casearia battiscombei* R. E. Fries. 1-2 years in ground, 2-3 years below ground (K.B. 15)				
66. *Cassia abbreviata* Oliv	?72	97+	97+	97+
67. *Cassia saimea* Lam. Pit props Nigeria (exotic)				
68. *Cassipourea elliottii* Alston. 2-4 years in ground (K.B. 9) Durable but not entirely termite-resistant (E.) Termite-proof pole Kilimanjaro.	2	91	43	12
69. *Cassipourea mollis* Alston	2	17	97+	37+
70. *Cassipourea ruwenzorensis* Alston. Less than 2 years in ground (K.B. 9)				
71. *Catha edulis* Forssk.	7	43	91+	?36
72. *Celtis durandii* Engl. 2 years in ground, 3 years underground (K.B. 15)				
73. *Celtis kraussiana* Bernh. 1-2 years in ground, 2-3 years underground (K.B. 15)				
74. *C.* (?) *soyauxii* Engl. Perishable to fungi (F.)				
75. *Celtis soyauxii* Engl. 1-3 years in ground, 2-3 years below ground (K.B.15). Round Timber improved by creosote.				
76. *Celtis zenkeri* Engl. Non-durable (E.) Round Timber showed improved durability with creosote (S.)				
77. *Ceriops candolleana* Arn.	37	97+	97+	37
78. *Chlorophora excelsa* Benth. and Hook.f. Very durable practically termite-proof and teredo-proof, resistant in water (E.) Very resistant to fungi (F.) Untreated heartwood attacked by teredo in 6 months, Takoradi Harbour. Creosoted specimens unaffected in 6 months. Sapwood highly susceptible to Bostrychids. Heartwood immune (K.) Slightly inferior to teak in teredo-resistance (Sk.)	91+	91+	91+	91+
79. *Chrysophyllum albidum* G. Don. Very perishable in ground (E.) Untreated heartwood lost more than 50% in 21 months.				
80. *Chrysophyllum zimmermannii* Engl.	½	12	24	20
81. *Chrysophyllum sp.* Kuti.	½	12	91+	43
82. *Cistanthera parvifolia* M.B. Moss. Not durable (K.C.)				
83. *Clausena melioides* Hiern. 1½ years in and 2-3 years underground (K.B. 15.)	½	4	43+	43+
84. *Cola cordifolia* R. Br. Perishable (E.)				

REPUTED AND TESTED DURABILITY, EAST AFRICAN TIMBERS (PROVISIONAL LIST)—*Contd.*

Systematic Name	Morogoro Test Pieces: Un-treated	Sod. arsenite	Creo-sote	Merc. chloride
	Months before heavy attack			
85. *Combretum binderianum* Ketchy (now correctly *C. collinum* Fresn.) as *C. fischeri* Engl.	16	37	97+	37+
86. *Combretum imberbe* var *petersii* Engl. and Diels. Strong hard and durable underground but somewhat brittle (S. Rhodesia mines) immune to termites (Fu.)				
87. *Combretum molle* R. Br. ex G. Don.	8	37	37+	37
88. *Combretum schumannii* Engl. Probably more than 5 years in ground (K.B. 9)	?72	91+	91+	91+
89. *Combretum zeyheri* Sond.	43+	?84	?84	?72
90. *Conopharyngia holstii* Stapf. Probably 2-4 years in the ground (K.B. 15)	½	8	91+	18
91. *Cordia holstii* Guerke. 1½-2 years in ground, 2-3 years below ground (K.B. 15.) Durable pole charred at base Kilimanjaro	4	18	84	26
92. *Cordyla africana* Lour. Tanganyika military sleepers.	43+	?84	91+	91+
93. *Cornus volkensii* Harms (now correctly *Afrocrania volkensii* Hutch.): 2-4 years in ground (K.B. 9)Perishable (E.)				
94. *Craibia elliotii* Dunn. Suggested for pit props (K.B. 15.)				
95. *Crossopteryx febrifuga* Benth. Very durable (E.) Durable in Nigeria.				
96. *Croton asperifolius* Pax. Less than two years in ground. (K.B. 9)				
97. *Croton macrostachys* Hochst. ex A. Rich. Less than 2 years in ground. Very perishable (E.)				
98. *Croton megalocarpus* Hutch. 1-2 years in ground; 2-3 years underground (K.B. 15) Perishable (E.)				
99. *Croton* sp. *Mpululu*	½	43	91+	?40
100. *Cussonia spicata* Thunb. Less than 2 years in ground (K.B. 9) Very perishable (E.)				
100 (*a*) *Cyathea* sp. Tree fern yielding durable posts				
101. *Cylicodiscus battiscombei* Bak. f. Less than 2 years in ground (K.B. 9) Kenya military sleepers.	11	44	91	26+
102. *Cynometra alexandri* C.H. Wright. Very durable (E.) Uganda military sleepers. 16 pieces of 20 lost less than 50% of the heart-wood (untreated) in 66 months (S.)? Immune to Bostrychid attack (K.)				
103. *Dalbergia melanoxylon* Guill. and Perr. Very durable. Sapwood very susceptible to Bostrychid attack (K.)				
104. *Dalbergia stuhlmannii* Taub. Durable hut-poles				
105. *Dalbergia ochracea* Harms. Durable hut-poles				
106. *Daniellia oliveri* Hutch. and J.M. Daltz. Untreated heartwood 27 months (S.)				
107. *Dialiopsos africana* Radlk. Tanganyika sleepers	97+	97+	97+	97+
108. *Dichrostachys glomerata* Chiov. Immune to termites (F.)				
109. *Diospyros mespiliformis* Hochst. Sleepers				
110. *Dodonaea viscosa* L. Not durable (K.C.)				
111. *Dombeya mastersii* Hook. f. 2-4 years in ground (K.B. 9)	½	5	91+	18
112. *Dovyalis abyssinica* Warb. 2-4 years in ground (K.B. 9)				
113. *Drypetes battiscombei* Hutch. 2-4 years in ground (K.B. 9)				
114. *Ehretia cymosa* Thonn. Perishable (E.)				
115. *Ehretia silvatica* Guerke. Less than 2 years in ground (K.B. 9)				
116. *Ekebergia ruppeliana* A. Rich. Less than 2 years in ground (K. B. 9)	½	6	91+	12+
117. *Elaeis guineensis* Jacq. Quickly eaten by termites (E.)				
118. *Elaeodendron stuhlmannii* Loes.	4	16	97+	16
119. *Entandrophragma angolensis* C. DC. Only moderately resistant to decay (E.)				
120. *Entandrophragma bussei* Harms. Very durable	97+	97+	97+	97+
120. *Entandrophragma cylindricum* Sprague. May prove more durable than other (?Uganda) mahoganies (E.)				
122. *Entandrophragma caudatum* Sprague. Untreated heartwood un-attacked in 11 years (D.)				
123. *Entandrophragma stolzii* Harms. Bridges? S. Highlands Tang. Territory	2	8	37	37
124. *Erythrophleum africanum* Harms. Sleepers, durable poles. Accepted sleeper S. A. Railways, Recommended mines Congo with reserve as to strength. Untreated heartwood unattacked in 11 years (D.)	84?	97+	?90+	97+

REPUTED AND TESTED DURABILITY, EAST AFRICAN TIMBERS (PROVISIONAL LIST)—*Contd.*

Systematic Name	Morogoro Test Pieces			
	Un-treated	Sod. arsenite	Creo-sote	Merc. chloride
	Months before heavy attack			
125. *Erythrophleum guineense* G. Don. Reputed fire and marine borer resistant, very durable as bridge piles (D.) Very durable and almost completely resistant to borers and termites (E.) Kenya, Uganda and Tanganyika military sleepers. 19 of 20 pieces of untreated heartwood lost less than 50% in 66 months. Moderately susceptible to Bostrychids (K.)				
126. *Fagara macrophylla* Engl. 2 years in, 2-4 years underground (K.B. 15)				
127. *Fagara merkeri* Engl.	97	37+	97	37+
127. *Fagara usambarensis* Engl.	16	16	16	37+
129. *Fagara* sp. near *F. macrophylla* Oliv. Durable in farm gates and boats (K.C.)				
130. *Faurea saligna* Harv. Probably more than 5 years in ground (K.B. 9) Reported borer and termite-resistant Congo. House piles Transvaal. Partly resistant to termites (Fu.)	43	16	91	43
131. *Faurea speciosa* Welw. Durable and termite-resistant (E.)				
132. *Ficalhoa laurifolia* Hiern.	½	43+	16	16
133. *Ficus brachypoda* Hutch. Hutbuilding poles Masaka (E.)				
134. *Ficus hochstetteri A.* Rich. Less than 2 years in ground (K.B. 9)				
135. *Ficus* sp. *F. sycamorus* 6 years with sod. arsenite (D.)	1	3	97	16
136. *Flueggea virosa* Baill. Said to be durable (E.)				
137. *Funtumia latifolia* Stapf. Less than 1 year in ground (K.B. 15)				
138. *Gardenia jovis-tonantis* Hiern. Probably resistant to insect attack (E.)				
139. *Gymnosporia rehmannii* Szysz. Durable (E.)	½	12	91+	16
140. *Gymnosporia* sp.	14	16	91+	43+
141. *Hagenia anthelmintica* J.F. Gmel. Not durable and subject to insect attack (E.) Termite-proof pole Kilimanjaro.	4	91+	91+	?36
142. *Harungana madgascariensis* Lam. Liable to insect attack (E.) 2-4 years in ground (K.B. 9)				
143. *Heritiera littoralis* Dry and. Moderately durable Malaya.	37	37	?97	37
144. *Hexalobus monopetalus* Engl. and Diels. Durable (E.) recomended hutpole (S.)				
145. *Holoptelea grandis* Mildbr. Liable to termite attack (E.)				
146. *Hymenocardia acida* Tul. Very durable, highly resistant to termites, tree 15-30 feet (E.) recommended hut-pole (S.)				
147. *Hypericum lanceolatum* Lam. Durable as poles at high altitudes (K.C.)				
148. *Isoberlinia globiflora* Hutch. ex Greenway. Tanganyika sleeper. Durable in mines if treated (S. Rhodesia)	2	37+	84+	37+
149. *Isoberlinia paniculata* Hutch. ex Greenway. Lasted nearly 6 years with arsenic salt (D.)				
150. *Isoberlinia tomentosa* Hutch. Lasted nearly 6 years with arsenic salt (D.)				
151. *Isoberlinia* spp. Common species lasted untreated 2-3 years in ground (D.)				
152. *Juniperus procera* Hochst. Extremely durable and almost immune to termites (E.) Reputed durable in water and not subject to borers. Lasting more than 10 years in ground (K.B. 9) Durable poles. Electric transmission poles. 6 out of 10 pieces of untreated heartwood lost less than 50% in 66 months (S.)				
153. *Khaya anthotheca* C. DC. Moderately durable (E.)				
154. *Khaya grandifoliola* C.DC. Not durable (E.)				
155. *Khaya nyassica* Stapf.	43+	43+	?91+	43
156. *Khaya senegalensis* A. Juss. Not very durable in ground but more termite resistant than any other species of (?Uganda) Khaya (E.)				
157. *Kigelia aethiopica* Decne.	½	10	20	18
158. *Klainedoxa gabonensis* Pierre. Very durable (E.)				
159. "*Lachnopylis liebenlistii*"	1	37	?97	37
160. *Lasiodiscus mildbraedii* Engl. Recommended hut-pole ?(S.)				
161. *Lasiosyphon glaucus* Fresen.	1	3	97+	37
162. *Lecaniodiscus ?fraxinifolia* Bak. Durable mines, Musoma, T.T.				
163. *Lonchicarpus capassa* Rolfe.	3	14	20	14
164. *Lonchocarpus eriocalyx* Harms	2	37	97	37
165. *Lovoa swynnertonii* Bak. f. Very durable. Borer-resistant (E.)	18	20	43	43+
166. *Maba abyssinica* Hiern. 1½-2 years in, 2-3 years underground (K.B. 15) Kenya military sleepers. Not durable (E.)	3	18+	33+	18+
167. *Maba buxifolia* Pers.	½	5	91	12

REPUTED AND TESTED DURABILITY, EAST AFRICAN TIMBERS (PROVISIONAL LIST)—*Contd.*

Systematic Name	Morogoro Test Pieces — Months before heavy attack: Untreated	Sod. arsenite	Creosote	Merc. chloride
168. *Macaranga kilimandscharica* Pax. Less than 2 years in ground (K.B. 9) ..				
169. *Measa lanceolata* Forssk. Hut-poles, Usafwa, Tanganyika T.				
170. *Maesopsis eminii* Engl. Probably 4-5 years in, 5 years underground (K.B. 15) Not termite resistant (E.) Not resistant to fungi (F.) Sap and heartwood readily absorb creosote under pressure ..	8	37	97+	37
171. *Malacantha* cf. *M. Superba* Vermo. Perishable (E.) ..				
172. *Manilkara cuneifolia* Dubard vide *Mimusops cuneifolia* Bak. ..				
173. *Marattia* sp. This forest fern does not produce posts. (see under *Cyathea*). ..				
174. *Markhamia hildebrandtii* Sprague. Termite proof poles Amani.				
175. *Markhamia obtusifolia* Sprague ..	2	14	97+	38
176. *Markhamia platcalyx* Sprague. Probably more than 10 years in and underground (K.B. 15) Moderate resistance against termites durable against decay (E.) Recommended as hut-pole (S.) ..	1	10	97+	37
177. *Mildbraediodendron excelsum* Harms. Of 20 pieces of untreated heartwood none lost 50% in 66 months (S.) Moderate susceptibility to Bostrychids (K.) ..				
178. *Millettia oblata* Dunn. 2-4 years in ground (K.B. 9) This and possibly several others reputed durable poles. Some resistant to mechanical wear. ..	?91	91	91	84
179. *Minusops aedificatoria* Mildbr. Durable pole? ..				
180. *Minusops cuneifolia* Bak. Exceptionally strong and durable (E.) Probably over 10 years in ground (K.B. 15) Kenya military sleepers. ..	97	37+	97	97
181. *Mimusops densiflora* Engl. Durable hut-pole Usukuma. ..	37	37+	37+	37+
182. *Mimusops usambarensis* Engl. Probably more than 5 years in ground (K.B. 9) ..				
183. *Mitragyna rubrostipulacea* Havil. Less than 2 years in ground (K.B. 9) ..	2	12	43+	12
184. *Mitragyna stipulosa* O. Ktze. Durable in water (E.) ..				
185. *Monotes adenophyllus* Gilg. Termite proof poles. Sleepers Tang. Central Line. ..				
186. *Monotes africanus* C. DC. Lasted 5 years with arsenic salts (D.)				
187. *Morus lactea* Mildbr. Less than 2 years in ground (K.B. 9) Pier piles 15 years Victoria Nyanza. Highly susceptibility to Bostrychids (K.) Perishable (E.) ..	40	43	?72	?72
188. *Myrianthus arboreus* P. Beauv. 2-4 years in ground (K.B. 9). Perishable (E.) ..				
189. *Myrianthus holstii* Engl. ..	1	10	37+	37
190. *Myrica kilimandscharica* Engl. (now correctly *M. salicifolia* Hochst. ex A. Rich.) ..	1	8	37	8
191. *Neoboutonia macrocalyx* Pax. Less than 2 years in ground (K.B. 9) Perishable (E.) ..				
192. *Ochna stuhlmannii* Engl. 2-4 years in ground (K.B. 9) ..				
193. *Ocotea usambarensis* Engl. 2-4 years in ground (K.B. 9) Tang. military sleepers, Very resistant to fungi (F.) Sapwood slightly attacked by Bostrychids (K.) ..	14	20	? 90	?84
194. *Olea chrysophylla* Lam. More than 10 years in ground (K.B. 9) Very durable (E.) ..	84	84	91+	91+
195. *Olea hochstetteri* Bak. 2-4 years in ground (K.B. 9) Kenya military sleeper. Moderately resistant to fungi (F.) ..				
196. *Olea schliebenii* Knobl. Termite-proof pole, Uluguru. ..				
197. *Olea welwitchii* Gilg. and Schell. Vide *Steganthus welwitchii* Knobl. ..				
198. *Olea sp.* Olmase. Meru Mountain ..	½	20	20	12
199. *Olinia usambarensis* Gilg. 2-4 years in ground (K.B. 9) ..				
200. *Ostryoderris stuhlmannii* Dunn. Tanga military sleepers. (Specimen piece described as unseasoned). ..	5	18	43+	36
201. *Osyris wightiana* Wall. (Sandalwood substitute) ..	36	43+	84	84
202. *Oxystigma msoo* Harms. ..	½	7	91+	20
203. *Pachystela brevipes* Engl. Durable (E.) ..	16	16+	97+	16+
204. *Pachystela msolo* Engl. ..	½	14	91+	30
205. *Pappea ugandensis* Bak. f. ..	16	37	97	37+
206. *Parinari excelsa* Sabine. Reputed very durable (E.) 11 pieces of 20 untreated heartwood lost more than 50% in 15 months (S.) See No. 207. ..				
207. *Parinari holstii* Engl. (Synonym of No. 206) ..	2	?30	97	37
208. "*Parkia africana*" R. Br. ..	1	16	97	37+

REPUTED AND TESTED DURABILITY, EAST AFRICAN TIMBERS (PROVISIONAL LIST)—*Contd.*

Systematic Name	Morogoro Test Pieces			
	Un-treated	Sod. arsenite	Creo-sote	Merc. chloride
	Months before heavy attack			
209. ***Phialodiscus unijugatus*** **Radlk. Durable (E.)**				
210. ***Phoenix reclinata*** **Jacq. Reputed durable. Termite and fungus resistant ; much used in building (E.) ?Durable in water.** ..				
211. *Piptadenia africana* Hook. f. Seasoned timber reputed termite resistant (E.) Uganda military sleeper. Moderately susceptible to Bostrychids (K.)				
212. *Piptadenia buchananii* Bak. Less than 2 years in ground (K.B. 9) Very durable in fresh water (K.C.) Sleepers? See No. 214 ..				
213. *Piptadenia hildebrandtii* Vatke.	37+	97+	97	97+
214. *Piptadenia schweinfurthii* Vatke ex. Engl. (Synonym of 212.) ..	4	43	91+	43
215. *Pittosporum abyssinicum* Del. Probably more than 5 years in ground (K.B. 9) Durable, very suitable hut-poles (E.) ..				
216. ***Pleurostylia africana*** **Loes.**	17	17	97+	?17+
217. *Podocarpus gracilior* Pilg. Less than 2 years in ground, all 16 pieces of untreated heartwood lost more than 50% in 15 months (S.) Immune to Bostrychids (K.)	1	8	97+	37
218. *Podocarpus milanjianus* Rendle. 2-4 years in ground. Immune to Bostrychids (K.)				
219. *Podocarpus usambarensis* Pilg. All 10 pieces lost more than 50% of untreated heart in 18 months (S.)	½	43	91+	43+
220. *Polyscias ferrugineum* Harms. Less than 1 year in ground and about one year underground (K.B. 15)				
221. *Polyscias kikuyuensis* Summerhayes. Less than 2 years in ground (K.B. 9)				
222. *Premna angolensis* Geurke. Probably 5 years in and underground (K.B. 15) Not durable (E.)				
223. *Premna maxima* T.C.E. Fries. Probably more than 5 years in ground (K.B. 9)				
224. *Pseudospondias microcarpa* Engl. Perishable (E.)				
225. *Psychotria* sp. (Timber tree) Reputed durable (K.C. p. 146).				
226. *Pteleopsis myrtifolia* Engl. and Diels	26	?85	?91+	?91+
227. *Pterocarpus angolensis* DC. Very resistant to fungi (E.) Untreated heartwood unattacked in eleven years (D.) Immune to termites (Fu.) S.A. Railways and Central Line Tanganyika sleepers. Congo mines. Slightly susceptible to Bostrychids in sapwood (H.) Resistant to teredo (Sk.)	36	?48+	?48+	?48+
228. *Pterocarpus* sp. Probably *P. odoratus* De Wild. Mkurungu Tanganyika military sleepers. 15 years in a mine				
229. *Pterocarpus* spp. *Pterocarpus chrysothrix and* probably other species included under the same native name have possibly similar durability.				
230. "*Pterocarpus* sp. nov." Mkurungu.	97	97	97+	97+
231. *Pterocarpus zimmermannii* Harms.	8	43	91+	43+
232. *Pycnanthus kombo* Warb. Quickly attacked by borers and fungi (E.)				
233. *Pygeum africanum* Hook. f. Probably 2 years in and 2-4 years underground (K.B. 15) Kenya and Uganda military sleepers. Durable (E.)	43+	43	91+	43+
234. *Rapanea neurophylla* Mez. Perishable, subject to borers (E.) ..				
235. *Rapanea rhododendroides* Mez. 2-4 years in ground (K.B. 9) ..	½	12	43+	43
236. *Rauvolfia inebrians* K. Schum.	½	16	91+	14
237. *Rawsonia usambarensis* Engl. and Gilg. More than 5 years in ground (K.B. 9)	½	16	91	14
238. *Rhizophora mucronata* Lam. Very common hut-pole (coast). ..	37	37+	?60	37+
239. *Sapium ellipticum* Pax. 1-2 years in ground, 2-3 years under ground (K.B. 15)				
240. *Schrebera alata* Welw. Probably more than 5 years in ground (K.B. 9)				
241. *Schrebera koiloneura* Gilg.	4	?24	97	37+
242. *Securidaca longipedunculata* Fresen. Reputed rot and termite-resistant (E.)				
243. *Sonneratia acida* L. f.	10	37+	13	37+
243a. *Spirostachys africana* Sond. Hut poles outlasting five reconstructions Morogoro				
244. *Steganthus welwitschii* Knobl. Probably over 10 years in and below ground (K.B. 15) Extremely durable and termite resistant (E.)	2	18	?84	43
245. *Sterculia appendiculata* K. Schum. Subject to borers				
246. *Sterculia quinqueloba* K. Schum. Heartwood reported durable but not termite resistant Congo.	90	91	86	91+
247. *Stereospermum kunthianum* Cham. Durable pole	4	16	97+	37+

REPUTED AND TESTED DURABILITY, EAST AFRICAN TIMBERS (PROVISIONAL LIST)—*Contd.*

Systematic Name	Morogoro Test Pieces			
	Un-treated	Sod. arsenite	Creo-sote	Merc. chloride
	Months before heavy attack			
248. *Strombosia Scheffleri* Engl. Termite-proof pole ? Kenya military sleeper (*as S. grandifolia*). Durable (E.)				
249. *Strychnos heterodoxa* Gilg.	2	17	97+	37+
250. *Strychnos* sp. Kenya military sleeper. Slightly susceptible to Bostrychids (K.)				
251. *Swartzia madagascariensis* Desv.	97+	97+	97+	97+
252. *Symphonia gabonensis* Pierre var. *macrantha* Hutch and J.M. Dalz. Very resistant to fungi (F.) Liable to insect attack (E.)				
253. *Syzygium guineense* DC. Very durable (E.) lasted 5 years with arsenic salts (D.)	1	6	97+	37
254. *Tamarindus indica* L. Reported resistant and used in construction Congo. Tanganyika military sleeper.				
255. *Teclea glomerata* Verdoorn.	37	37+	97+	97+
256. *Teclea nobilis* Del. 2-4 years in and 3-4 years underground (K.B. 15) Recommended hut-pole (S.)				
257. "*Teclea unifoliolata*" Baill.	1	6	37+	37
258. *Teclea viridis* Verdoorn.	2	12	24	26
259. *Terminalia aemula* Diels. ? Durable				
260. *Terminalia brownii* Fresen. Durable (E.) Recommended hut-poles.				
261. *Terminalia prunioides* Laws. Durable in salt-water and in the ground (K.C.)				
262. *Terminalia sericea* Burck. Reputed termite proof (Tropenpflanzer) Very good above and below ground, strong and tough but liable to crack (S. Rhodesia). Fence posts. Battery fingers. Hut-poles Unyamwezi. Immune to termites (Fu.)	½	12	91+	?36
262. *Terminalia spinosa* Engl. 15 years in ground, Moa coast, Tang. Territory				
264. *Tetrapleura tetraptera* Taub. Medium durability (E.)				
265. *Thespesia danis* Oliv. Durable (K.C.)				
266. *Trechylobium verrucosum* Oliv. Probably more than 10 years in ground (K.B. 9)	37	37	37+	37
267. *Trema guineensis* Ficalho. Less than 2 years in ground (K.B. 9)				
268. *Trichelia emetica* Vahl. 1 year in and 1-2 years underground (K.B. 15)				
269. *Turraea fischeri* Guerke.	2	16	97+	?72+
270. *Turraea robusta* Guerke. Termite-proof pole, Kilimanjaro				
271. *Tylostemon ugandensis* Stapf. Round timber in mines Ankole, durable (E.)				
272. *Uapaca guineensis* Muell. Arg. Durable (E.)				
273. *Uapaca kirkiana* Muell. Arg. Conflicting reports S. Rhodesia mines. Some considering it moderately borer and termite resistant. Lasted 5 years with arsenious oxide (D.)				
274. "*Vangueria edulis*"	26	43	91+	43+
275. *Vangueria linearisepala* K. Schum. Less than 2 years in ground (K.B. 9)				
276. *Vitex cuneata/Thonn.* Moderately durable if not exposed to damp	1	13	91+	?30
277. *Vitex keniensis* Turrill. 2-4 years in ground (K.B. 9)	2	13	97+	37
278. *Warburgia stuhlmannii* Engl.	91	91	91	91+
279. *Warburgia ugandensis* Sprague. 2-4 years in ground (K.B. 9) Kenya military sleeper. Not durable or termite resistant (E.)				
280. *Xymalos monospora* Baill. Probably more than 5 years in ground	½	11	18	11
281. *Ziziphus mauritiana* Lam. Durable (E.) Recommended hut-pole (S.)				
282. *Ziziphus mucronata* Willd.	16	37+	97+	37+

TIE-RIDGING

With Special Reference to Semi-arid Areas

By A. N. Prentice (Empire Cotton Growing Corporation) Lubaga Experiment Station, Shinyanga, Lake Province, Tanganyika Territory

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Tie-ridging—ridging with the addition of cross-ties in the furrow at short intervals, as shown in Photograph 1—is a method of water and soil conservation that has not had the attention it deserves. It is simple and effective, but it rarely gets more than a passing mention in the agricultural literature.

The term tie-ridging, or ridge-tieing, is perhaps not too happily chosen; but it probably arose when tieing was added to the ridging already practised in north Sukumaland and the term seems to be firmly established and moderately well understood in Tanganyika. The nearly-synonymous "basin-listing" of America is only more descriptive if one happens to know that a "lister" corresponds to a ridging plough.

Interest in tie-ridging seems to be recent. The agricultural literature in the U.S.A. contains numerous references to basin-listing from 1930 onwards. In East Africa, Staples [1] reports as early as 1933 that "Ridge cultivation on the contour, if tied every six feet, proved to be the most effective means of preventing run-off". The back numbers of this Journal make occasional and usually brief mention of tie-ridging. Tie-ridging in West Africa has had at least two publicists in Stamp [2] and Faulkner.[3]

Doubtless there are many references to tie-ridging in Colonial Departmental files, but from conversation with many officials in Tanganyika I would say that knowledge of tie-ridging—of its very existence, let alone of its pros and cons—is at best very uneven. A most practicable measure—if it is *good* tie-ridging—giving complete protection against erosion by water on arable land is little known and less used over much of Africa where it would be suitable. Tie-ridging brings its own crop of problems, but in the semi-arid parts of Africa it has an important part to play.

Experimental Evidence from Lubaga

The local background.—Lubaga Experiment Station lies in what has been called the "arid hinterland of the Lake Province". The rains show no marked division into "long" and "short"; the wet season with a very variable rainfall averaging about 31 inches lasts for six to seven months, and the rest of the year is dry. Much of the rain falls in heavy downpours; in the season 1943–44 the four heaviest falls of the season accounted for over 40 per cent of the year's rainfall, and even in less extreme seasons comparatively few falls account for a disproportionately large amount of the total. To labour this point of the within-season maldistribution of rainfall—the clue to the failure from drought of so many crops that are not tie-ridged—the 12-year record at Lubaga shows that in an average wet season the expectation is something like seven storms (i.e. 24-hour falls) of between one and two inches and two storms of between two and five inches. This is important in relation to tie-ridging. The Lubaga type of rainfall is similar to that of much of Tanganyika, and indeed to that of much of Africa.

The soils on the station are agriculturally fairly heavy; the main soil is a black loam, fertile but shallow and rather poor in permeability, and the other soil-type is a hardpan, also of good nutrient status but almost impermeable and particularly difficult to work. The land is gently rolling.

The native custom here is to plant the major crops, sorghum and cotton, on the flat. Flat cultivation is therefore taken as the normal or "control" method of cultivation.

Actual trials.—The simplest way to assess the value of tie-ridging is to find the comparative yields of crops under flat and tie-ridged treatments. Trials, specifically testing the effect on yield of different methods of cultivation, have been running on Lubaga since 1939. The results from 1939 to 1946 are given in the following table:—

LUBAGA YIELD TRIALS, 1939-46: FLAT VERSUS TIE-RIDGED

Expt. No.	Year	Rain	Plot size acres, and No. of replications.	Crop	Yield in Pounds Per Acre (seed-cotton or clean grain unless noted)		Tie-Ridged compared Flat=100.	
		Inches			Flat	Tie-Ridged	Flat	Tie-R.
I	1939	24	1/40(6)	Cotton	288	483	100	167
II	,,	,,	1/40(6)	Sorghum	180	654	100	363
III	1940	31	1/40(6)	Sorghum	720	1000	100	139
IV	1942	49	1/127(24)	Cotton	935	761	100	82
V	1943	23	1/127(24)	Maize	153	735	100	480
VI	,,	,,	1/43(8)	Cotton	550	760	100	138
VII	1944	26	1/30(8)	Cotton	90	350	100	390
VIII	,,	,,	1/20(40)	Sorghum	760	775	100	102
IX*		,,	1/6·7(3)	Sorghum†	306	711	100	233
X*	1945	31	1/6·7(3)	Cotton	610	1100	100	180
XI*	,,	,,	1/6·7(3)	Sorghum‡	1395 (straw)	3340	100	239
XII	,,	,,	1/6 (4)	Sorghum	870	795	100	91
XIII	,,	,,	1/8·1(12)	Sorghum‡	2775 (straw)	3390	100	122
XIV	1946	13‡	1/5·0(8)	Cotton§	64	166	100	254

Significance ($P = \cdot 05$): in all experiments *except* No. VIII and No. XII, the difference between the two methods of cultivation is significant.

Notes—*Soil-type: Experiments IX, X, and XI were the hardpan soil, an extreme and possibly uncommon type; all other experiments were on the black loam.

†Grain heads, not clean grain.

‡Straw weights used; grain-heads spoilt by insect attack.

§To 8/4/46 only, time of the first picking; drought year, rain half of normal to date.

Results like these are impressively in favour of tie-ridging. Differences of the order shown between flat and tie-ridged are uncommon in agricultural comparisons; the very large differences, such as those shown in Experiments II or V, virtually represent the difference between "failed" and "not failed" crops, but the run of differences is still important. Observation in the field bears out the yield figures; I did not see Experiments I and II, as I did not take over Lubaga from Mr. J. G. M. King until the end of 1939, but I am told they were as striking in the field as were most of the later experiments. (Photographs 2–5 may give some idea of the growth differences, which were, of course, reflected in the yield in a typical experiment, No. X.) Observation plots on Lubaga from as early as 1937, as well as fields under bulk crops in later years, and trials and demonstration plots in the district, confirm this superiority of tie-ridging over flat cultivation. Each soil-type doubtless differs in its response to tie-ridging, possibly markedly, and more evidence, especially from district plots, is very desirable on this score, but the case for tie-ridging seems broadly proved.

Other yield factors were also under test in some of the experiments listed. It is fair to say that with the Lubaga soils the effect of tie-ridging is usually so large as to relegate to the background the effects of other factors. The method of cultivation seems to show little or unimportant interaction with manuring or strain or spacing, i.e. both tie-ridging and flat respond in much the same way to these influences, although all this side of the work needs further checking. Size of ridge has not been sufficiently tested to warrant any strong opinion about the best size, if there is a best; "tie-ridging" throughout this article means a parent ridge from three to 5 feet from crest to crest, usually four feet.

Experience at Ukiriguru

Ukiriguru, the larger experiment station further north in this Province, is in an area where ridging (with the large ridge, about five feet from crest to crest) is established practice. The natural development on the station was to get well made ridges on the contour, and then tie; and since 1939–40 ridge-tieing has been routine on some hundreds of acres of hill sands. The only soils on the station not cultivated on this system are the flat low-lying valley soils (the *mbuga* lands of the local tribe) and the local hard-pan soil, of bad drainage.

The hill sands of Ukiriguru are much more permeable than the soils of Lubaga, but even so a heavy rain removes the finer and more valuable fraction of the soil where the ridges are not tied—this deplorable loss can be seen

after any heavy storm in the ridged but untied native fields adjoining the station. The slopes on the station, up to 7 per cent, are much steeper than those on Lubaga, and although the ridges are approximately on the contour, field-scale trials need straight rows, and only the good permeability of the soils plus tie-ridging save Ukiriguru from erosion. Every year since 1939–40, tie-ridging has been of marked benefit.

The individual fields on either station are not large by European-in-Africa standards, but are big enough (up to 20 acres) to have revealed any mass-effect that might have been missed in the plot-scale stage.

Ridging and Contour-banking Compared with Tie-ridging

Tie-ridging, regarded as closed-end terracing carried to an extreme, falls into the category of engineering methods of erosion-control. This article is not directly concerned with the more strictly agricultural or biological methods of increasing the water-absorbing powers of soils, very important though grass-rotation, for instance, may be; such methods are complementary to, rather than competitive with, tie-ridging. And farming on the contour as far as practicable is taken as axiomatically desirable, whatever other measures are used to the end of conservation. But, other things being equal, tie-ridging calls for comparison with other of the "engineering" methods, in particular ordinary ridging and contour banking, methods with which some local experience is available.

Ridging.—Does ordinary ridging, then, fail to do anything that tie-ridging can do? Most decidedly, although the local evidence is not as complete or objective as it might be. As a treatment in trials, ridging has been included too rarely to generalize, but trials and observation together place ridging as probably between flat and tie-ridging in its effect on yield. (A difficulty in the comparing of ridged, tie-ridged and flat methods is that unless the plots are very large, ridged treatment is protected at the ends of the furrows by paths and, incidentally, flat is protected from grosser erosion by the mere presence of paths and other-treatment plots. Experience suggests the need for very large plots in such trials.) Ridging, in itself an intermediate step to tie-ridging, just misses the mark for want of the ties. Stamp [2] is emphatic about the dangers of ridging without tieing: ". . . the introduction of the plough into the light land of northern Nigeria is liable to prove a curse which will more than outweigh the blessing conferred by mixed farming. Every furrow is a water-course taking off the needed water, every one an incipient erosion gully . . . . nor is contour-ploughing in this gently undulating plain land sufficient. Fortunately the local cultivator has already evolved a system which points the way . . . . ridges (from three to six feet apart and from nine inches to thirty inches high), crossed at intervals by ridges at right angles. Instead of the long straight plough-furrow, the result is a series of isolated basins. Into these are swept the finer particles of soil during a storm, but no soil is lost, for the basins fill with water, which later seeps away".

In specialized circumstances, well-graded ridging may provide drainage where that is desirable, and ridging is less laborious than tie-ridging, but by and large, ridging can be dismissed as seriously incomplete without ridge-tieing.

Contour banking.—Usually, in this part of the world, contour banking implies flat cultivation on the between-bank stretches. The banks, or the stop-wash lines, are there to deal with the run-off from above.

On Lubaga, on gently rolling land with normally a 1½ feet drop between "contour" banks and a 1 in 400 fall along the banks, the fields were showing signs of terracing under flat cultivation. The between-bank strips were giving visibly better crops on the down side, due no doubt to the soil and water gained from the top stretches. Erosion is obviously hindered by contour-banking, but is certainly not stopped. Sheet and rill erosion has already started under flat cultivation, in No. X experiment; the soil type is admittedly very erodible, but nevertheless the field would have been passed as safeguarded on usual standards by the old contour-bank system of the farm, and, moreover, the field is in only its second year from grass. This particular experiment and two others on the rather more absorbent black-loam soil are being continued on the same sites, with the plots retaining their position, to measure any cumulative effect of erosion there may be over a period of years, using crop-yield as the criterion. I forecast a progressive worsening of yield under flat cultivation, both absolute and relative to tie-ridging, however high the standard of farming.

The safe disposal of surplus water, a prime necessity in contour-banking, becomes a less urgent problem in tie-ridging, as ordinarily

there is no surplus water. The freak 10-inch cloudburst which breaks ties and ridges will be equally hard on banks and outlets. Commonsense dictates that even in a tie-ridged area there must be a drainage system to deal with storm-water from roads, paths and rocks. Even tie-ridging cannot stand a discharge from higher up the slope; the need remains for the community in a natural conservation area to act in unison.

Any method of soil conservation that allows discoloured water, however controlled, to run off, is also allowing some loss of soil. In better climates one or more of the usual methods of soil conservation may suffice, but for protecting sloping arable lands in semi-arid Africa, tie-ridging would seem to be the basic need. Contour banking is not enough. I remember a slogan at agricultural shows, "Keep the soil on the farm", but this could be put more accurately, if less pithily, as "keep the soil within plough-share reach of where it started". Soil which has moved forty feet or forty yards down towards the next contour bank cannot easily be put back again, but soil washed from a ridge to a tie-ridged furrow a foot or two away is still under the control of the plough or the hoe. Tie-ridging does two things, it holds all rain within a foot or two of where it falls and, as a result, it is a complete check to soil erosion by water (*See* Photograph 6.) The first function has an immediate (annual) effect on yield in areas where water seems the limiting factor to growth in most seasons, and propaganda to the individual would rightly stress this aspect of tie-ridging, but the second function, soil conservation, is all-important, taking the long or community view. Tie-ridging in a very "wet" season, at least on a few soil types, may even depress yields, but however abnormally wet the season is the anti-erosion benefit still holds.

Some Practical Aspects

The black loam soil of Lubaga does not form particularly good ridges. In dry weather the soil becomes powdery and its angle of rest, for practical purposes, is low. Under rain the soil is comparatively easily washed from the ridge into the furrow. Such traits lead of course to shallower and less efficient basins. This, and the fact that the soil is poor in permeability, must be kept in mind when generalizations are drawn from Lubaga experience. Most soils are more permeable and have better ridging properties than this black loam, thus the safety limits are wider on most other soils, and contouring need not be so accurate nor ties so close. On the other hand, the effect of tie-ridging may be relatively less spectacular on the more permeable and less erodible soils in which, for a given rainfall on land not tie-ridged, more of the rainfall is naturally retained. Moisture is a less extreme limiting factor to plant growth in the more permeable soils.

Remarks in this section apply to tie-ridging as a method of cultivation for annual crops, including cassava. Tie-ridging might see a grass ley over the difficult year of establishment before ties and ridges had lost their effectiveness—present indications here are that it may —and it might have some application in forestry. But by and large, tie-ridging is regarded here as an annual operation for the benefit of annual crops.

Farming on the station is, as far as practicable, on the contour—a logical accompaniment of the tie-ridging which is now routine for all crops. Ties are spaced at from one to three paces apart along the furrow. The more nearly the furrow is on the contour, the wider apart can the ties safely be, but three paces has been set as the arbitrary maximum limit. Where the furrowing of the field has gone a bit off the contour, the ties are made closer, but the actual distance is left to the discretion of the operator. Mounds and low spots, if cultivated at all, obviously need close tieing. No critical work has yet been done on this point of spacing of ties, but would be desirable, as the present spacing may be unnecessarily close and labour-consuming. The typical four-foot ridge on the farm has a furrow not more than about a foot deep, measured vertically. The tops of the ties are kept two or three inches below the level of the main ridges and the ties are therefore weaker than the ridges; thus if anything has to go in a storm, the ties go first. An acre under four-foot ridges has 3,630 running yards of drill, and the same number of basins if the ties are only a yard apart. With a one-inch rain, each basin receives about six or seven gallons of water. The theoretical capacity of such a basin when new, allowing for nine inch high ties, is rather over twenty gallons. The safety margin for a one inch rainfall is thus considerable, even with slow percolation, but, with the irregularities that are bound to occur in field-scale cultivation, a quick two-inch fall may overflow some ties. The more absorbent the soil the less the danger, and a protracted fall is much less

dangerous than a tropical downpour of the same amount. The heaviest fall recorded here was 4¾ inches in 1942, but that rain lasted throughout the night and did no damage to ties. (The only tie-ridged plots in 1942, however, were too small for a really fair field test.) In practice ties have occasionally broken here, nearly always in the larger fields where the ridges have gone appreciably off the contour. The state then is no worse, and no better of course, than with non-tied ridges on the same alignment. The obvious remedies are better alignment, closer tieing, deeper furrowing and the leaving of all low spots in grass. The fact that ties can break has to be faced, but that very realization is the first and most important step to countering the trouble. "The best dung for the land is the master's foot", and if the master does not mind getting his foot wet on occasion, he will find it instructive to watch his lands during a heavy storm. The experience can be chastening, as when soil, water, and pet ideas on protection, ties, and everything else, are swept away together, but is to be recommended.

Tie-ridging and wind erosion.—Erosion due to wind is fairly serious in Shinyanga. Offhand, tie-ridging might not be expected to have much effect on wind erosion. However, American and Candian experience favours listing (furrowing) as a good way of checking wind erosion, and the findings on the prairies doubtless apply to the cultivation steppe of Sukumaland. Tie-ridging on Lubaga certainly makes for a more even spread of maize straw, etc., after harvest; drifts of litter piled up by the wind against the nearest hedge used to be the common experience with flat cultivation. The retention of such plant residues on the land possibly does good in more ways than one, but no measure of the benefits has been attempted here.

Implements for tie-ridging.—The heavy hand hoe will doubtless remain the common tool for making ties in native lands. The operation is simplicity itself, a hoeing up of sufficient earth from the bottom of the furrow to make a tie or bar across the furrow. The need for adapting the degree of tieing to the immediate circumstances means that the idea is not entirely foolproof for the native, but no other method of soil preservation approaches tie-ridging in practicability. With hand cultivation, incidentally, the ties as well as the parent ridges can be planted, a point which appeals to the native cultivator.

Mechanical methods of tieing have been tried on Lubaga. At least one of the big American implement-making firms turns out a "basin-lister" which scrapes a pile of earth along the furrow and deposits it to form a tie or bar at mechanically set intervals. (The implement is meant for tractor draught and Lubaga is experimenting, unsuccessfully so far, with ways of adapting a machine to ox-draught.)

Home-made and rather primitive tie-ridgers are doing moderately good work on Lubaga. The back tines of old single-furrow ox-drawn cultivators are replaced by a scraper, a piece of metal sheet cut to approximately the shape of the cross-section of the furrow. The two front tines are left in place to loosen the soil in the furrow in front of the metal scraper. The implement is drawn by two oxen, yoked in tandem, as the usual yoking abreast would mean that one ox would have to walk in a furrow where the ties had already been made. The scraper collects loose earth from the bottom and sides of the furrow and pushes the small pile along the furrow for the necessary three to ten feet; the driver then lifts the back of the machine bodily to leave the pile behind as a tie. The machine in action is decidedly Heath-Robinsonian, but it gets the spade-work done. The drivers do not dislike the work and do not find the constant lifting unduly tiring. The efficiency of these machines could, no doubt, be vastly improved by someone with a mechanical bent. As they stand, their main usefulness here is in keeping fairly close behind the ridging ploughs, giving the newly-opened furrows a rough-hewn defence system against the sudden storm. A final hand-trimming of the ties is still very desirable, however, for greater efficiency. Ploughing, ridging, and tieing all follow in sequence as quickly as practicable. The home-made tie-ridger makes a fair job of cultivating in the growing crop, breaking down ties and rebuilding them as it passes. Its flexibility is an advantage in that the spacing of ties can be altered at will.

Limitations and Disadvantages of Tie-ridging

Tie-ridging is more laborious and therefore time-consuming than ordinary ridge cultivation, and much more so than flat cultivation. At the time of the planting rush this is important to the native in areas where he cannot prepare his land in the dry season, and is

commonly raised as his main objection to tie-ridging in Shinyanga. A sound though overstated objection on the part of the native is that an unusually wet year may lead to water-logging. It does, at least on certain soils, but the very wet year is uncommon enough to make the objection a minor one.

Sometimes there is more difficulty with ridge (or tie-ridge) than with flat cultivation in establishing a good stand. This is possibly due to the ridge drying out more quickly, or to light rains not penetrating the top of the ridge, but no work has been done on the point. In a season of light planting showers, however, the poorer stand on the ridge is a real fault on the local soils.

Tie-ridging in large-scale farming would come up against the very real additional difficulty of generally unsuitable implements for dealing with a tie-ridged crop through to harvest. It is at least arguable that the extra expense of tie-ridging on a farm scale would be justified by the better immediate yields and by the check to insidious erosion which may not be obvious to the eye. Possibly simplicity should be listed as a fault of tie-ridging, which to the public may not have the magic of "heavy machinery from America" which is big and expensive and unobtainable and must be good.

Extension to the Districts

Proving the efficacy of tie-ridging on an experiment station is one thing. "Putting across" an approved measure to the countryside is another.

Tie-ridging is only now being seriously tried in the districts, and can not yet be written up as a success in practice. However, there is now a strong movement towards the enforcing of tie-ridging in this quarter of Tanganyika. In the important Mwanza District of the Lake Province, the problem is to get the cultivator to add tieing to his present practice of ridging and to make better ridges. At the other extreme, Shinyanga District, where cultivation on the flat is the usual custom, the native will have to be led from flat to tie-ridged cultivation at one jump. A little, a very little tie-ridging, is now appearing in the districts away from the experiment stations or district demonstration plots. With pressure removed, it is doubtful if there would be any tie-ridging, as it is not popular.

Musoma District, lying between Sukumaland and the Kenya border, is a district where tie-ridging seems to have made some headway recently. I do not know Musoma, and am indebted to its Agricultural Officer, Mr. J. T. Purvis, for the following note: "To start with I set a maximum distance of five yards between the ties, pulling them closer when the ridges tended to run downhill. . . . Tie-ridging is possibly only worth while if the parent ridges are well made. . . . Where we have been able to get properly spaced ties on well-made ridges, I, and more important, the African cultivator, are satisfied that the crops do better in every way and this method is a complete answer to erosion in ridge cultivation." The Musoma style of tie-ridging differs somewhat from that practised on the experiment stations in that the ties as well as the ridges are large and more or less permanent, in effect ridges running downhill which need not be remade when the main ridges on the contour are split and remade for a new crop. This system in practice has stood up to storms of five inches.

Hard and fast rules cannot be laid down for tie-ridging, without much more experience; its application in the districts must be watched, recorded, and possibly corrected. The experimental attitude towards tie-ridging should be maintained when the measure gains acceptance in the districts. Milne [4] notes approvingly that the vast scale of American conservation works did not preclude a critical attitude on the part of the executives to their own work: "They were applying measures that would transform a landscape but they looked on their methods as experimental and were acquiring experience that might alter them."

Some Reflections

Tie-ridging in itself will not ensure good crops without care in other agricultural practices, and in the choice of a farming system reasonably well in harmony with the inherent agricultural circumstances. If rain always fell so gently on soil so permeable that it could be absorbed without any run-off, there would be no advantage in tieing, and the advantages, if any, of ridging would not be dependent on the soil- and water-conserving property of the ridge. But as it is, the rains are irregular and torrential over much of Africa, and moisture is often the limiting factor to plant growth. That ecological intruder the cultivated crop relies on man to make the moisture conform to its needs. Tie-ridging, by conserving moisture that would be lost to the plant under the usual ways of treating sloping arable land in the semi-arid regions, increases

the safety margin for crops. Rainfall would rarely be inadequate for normal growth of the local crops were it all held where it fell, within root-reach of the plant. Where the other conditions for plans are broadly right—and speaking of Shinyanga, I would say that the nutrient-status of the commonly-present darker soils,* where these are not eroded, is far from poor—sufficient moisture ensures good crops. A tie-ridged land yields some water to the underground supplies, and some to evaporation, but none to surface run-off. Tie-ridging smooths out the distribution of rainfall in space, and in effect in time, all-important where the rainfall is of the heavy storm type and the land is not flat. Incidentally, where a lower temperature does not come in as the limiting factor to growth after the finish of the rains, it actually extends the season; at Lubaga, this continuation of growth has been most noticeable on the hard-pan soil where both sorghum and cotton under tie-ridging kept green for one to two months longer, after the close of the rains, than did their counterparts under flat cultivation.

Basin-listing seems to be an approved and established measure of conservation in the lower rainfall areas of the United States. Tie-ridging and basin-listing show points of difference. In the States a basin-listed crop, at least sometimes, is one planted in the furrow. All tilled crops here are grown on the ridge, the only crop sown on the ridge and in the furrow being grass. The basin-lister obviously cannot deal with crops actually growing in the furrow, and the Americans must regard basin-listing as primarily a way of conserving rain which falls before and around planting, i.e. as a dry-farming measure, whereas tie-ridging here is meant to deal as much with the growing season as with the early season storms.

Although local propaganda for tie-ridging is justified, the subject is far from being fully understood, and it deserves further study as part of the broader problem of land usage. Many questions require to be answered; will the usefulness of tie-ridging be confined to the semi-arid belt with a rainfall below, say 40 inches, or will soil type rather than climate set the limits; will continued tie-ridging lead to undue leaching, and so on. Local work on a field scale is needed, and each area must be investigated separately. Possibly the first task is to measure erosion damage in the semi-arid areas under field conditions, as this has not yet been carried out on a reliable scale. The small "erosion run-off" plots of Shinyanga and Mpwapwa hardly count, although they served a purpose in putting soil and water losses from different treatments in order, but the absolute losses of soil are remote from soil erosion reality. In the Shinyanga red-soil plots the loss from the worst treatments (ridges up-and-down-hill, and flat cultivation) averaged a rate under four tons per acre per year over the last five years. These plots would, therefore, take well over a third of a century to lose their top inch of soil. Data of this kind are not good enough for framing agricultural policy. The erosion losses on the Mpwapwa run-off plots admittedly are many times greater, but the Mpwapwa plots are on a 6 per cent as against a 2 per cent slope at Shinyanga. The fact remains that the site of the Shinyanga run-off plots is typical of vast areas where the true erosion is very bad. As Staples says of erosion in semi-arid Tanganyika in general when the cover is seriously impaired by excessive stocking or faulty cultivation "it must be seen to be believed by those not familiar with such conditions". The true erosion picture is distorted in the miniature mirror of the plots. Milne [4] speaks of a strip-cropped plot, on a field scale, which had lost only 7 tons (per acre presumably), while down-slope rows under cotton in this same Texas experiment had lost 57 tons of soil. But as Milne himself says in a review in this Journal (July, 1940, p. 56), "Do not let us rely too much on American researches for light upon our East African problems; let us investigate for ourselves and start with the fundamentals".

Summary

Tie-ridging conserves soil and water by holding all rain in the basins formed by the cross-tieing or cross-barring of furrowed land. The measure, akin to the basin-listing of America, is not well known and is little practised in East Africa. Tie-ridging has its disadvantages but these are out-weighed by its advantages. It is a simply applied measure, and is very effective in raising yields in the semi-arid regions where lack of moisture, because of erratic distribution rather than sheer shortage of rainfall, is the limiting factor to plant

* Milne says, in a review in this Journal, January, 1936, p. 265, "The black soils of Africa, as a group present a challenge to the agriculturist. As contrasted broadly with its red soils, they contain an idle accumulation of the inorganic elements of fertility, and African agricultural science may increasingly be summoned to devise means of putting this stock into productive circulation."

growth. Other orthodox "engineering" methods of conservation, such as contour banking and ordinary ridging, cannot compete with tie-ridging in efficiency of holding water and soil. Where cultivation on the flat is the rule, as in Shinyanga, the change to tie-ridging gives very marked increases in yield. These claims are supported by yield figures from trials on Lubaga Experiment Station over the years 1939–46.

Tie-ridging is just beginning to make its way into district practice in parts of Tanganyika. It can be carried out by the native cultivator without any special machinery. Draught implements for making ties are known.

Good tie-ridging is a complete check on soil erosion by water.

ACKNOWLEDGMENTS

I have drawn freely on the experience of those members of the Agricultural Department now or recently stationed in the Lake Province. Mr. J. E. Peat (E.C.G.C.) of Ukiriguru and Mr. N. V. Rounce (Agricultural Department) of Mwanza read the draft of this paper and made many helpful criticisms.

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RATIONS FOR AFRICAN LABOUR

The Medical Specialist of the Tanganyika Labour Department in his publication "The Welfare of the African Labourer in Tanganyika" recommends as a typical ration for African labour:—

Maize meal: 28 oz. per day.

Beans: 4 oz. per day.

Groundnuts: 2 oz. per day.

Raw sugar: 1 oz. per day.

Meat: 1 lb. twice a week.

Red Palm oil: 2 oz. per week.

Other vegetable oils: 2 oz. per week.

Green leafy vegetables: 2 lb. per week.

Salt: 4 oz. per week.

This is in fact the ration laid down by the Tanganyika Government, provided the ingredients are in good supply.

There are, it is estimated, some 350,000 employed African in the Territory and although by no means all are fed by their employers, experience is shown that more and more are adopting this practice. Whether, however, they are fed by their employers or buy their own supplies, the food must still be made available. It is therefore considered of great practical importance to realize what acreage of land is necessary to provide the food required for employed Africans, and investigation has shown that the following acreages of land are required under present methods of fertility and cultivation:—

Per 100 *labourers at* 300 *days a year*

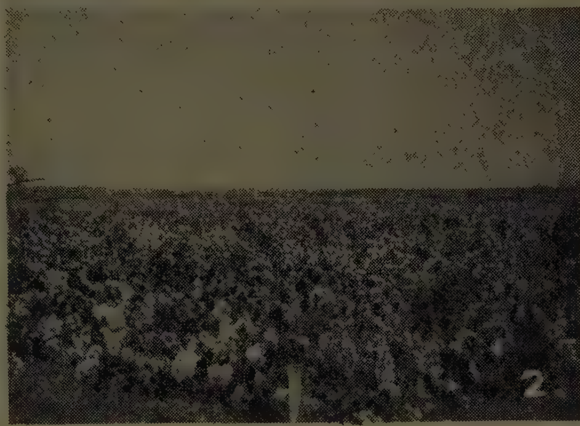
Maize	75	acres
Beans	25	,,
Groundnuts	9.4	,,
Groundnut oil	2.7	,,
Sugar	0.2	,,
Red Palm oil	3.0	,,
Green leafy vegetables	1.0	,,
Meat	500.0	,,
Total:	616.3	,,

To fulfil the dietary requirements of 350,000 labourers, therefore, 407,050 acres of arable land and 1,750,000 acres of pasture are necessary. Apart from pasturage, this implies that, unless grain and other vegetable foods are imported, every African peasant must devote about 10 per cent of his farming to the feeding of employed labour, and this is exclusive of the comparatively small contributions from non-native farms.

In good years an African farmer may well be able to spare ten per cent of his harvest—he certainly cannot do this after a poor season, and, unless the regular importation of large quantities of grains and beans from overseas is contemplated, it will be well for us to learn a lesson from Joseph and store up our surplus food after plentiful years, so that when the lean ones turn up production of minerals and export crops may not be retarded through lack of adequate food supplies for the African labourer.

24th June, 1946. R. W. R. MILLER.

TIE-RIDGING



1—Tie-ridging on hill-sands at Ukiriguru. The parent ridges are 5 feet from crest to crest.

2 and 3—Cotton on tie-ridged land at Lubaga: 2, a general view; 3, a typical plant (foreground plants cut out).

4 and 5—Cotton under flat cultivation, adjacent to the tie-ridged cotton of Fig. 2: 4, a general view; 5, a typical plant.

6—Tie-ridging at Lubaga.

COCO-NUTS ON TANGA COAST

Coco-nut trees on the banks of the Pangani River. Note interplanted betel nut palms.

An Arab copra-drying yard on the banks of the Pangani River.

Drying and extracting copra on the banks of the Pangani River. Note the dwarf bananas.

THE IMPROVEMENT OF THE COCO-NUT INDUSTRY ON THE TANGA COAST

By R. J. M. Swynnerton, M.C., B.A., Dip. Agric. (Cantab.), A.I.C.T.A.,
Agricultural Officer, Tanganyika Territory

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The coco-nut industry is of particular importance to the three coastal belts of East Africa, Zanzibar, Tanganyika and Kenya, and the three countries have been inter-dependent for their copra trade since the earliest days. Zanzibar, Mafia, Dar es Salaam, Bagamoyo, Pangani, Tanga, Moa, Vanga, Mombasa, the towns of the early Arab settlements, have drawn on each other for their supplies of copra, whether for local milling, grading up inferior qualities of copra or for export, and the chief carriers in the trade have continued to be the Arab dhows. Before the war the export of copra to the markets of Europe, or to those markets that would accept the local product, vastly inferior to Malaya or Ceylon, was rapidly giving way to local milling and oil extraction so that any apparent decrease in copra exports could be accounted for in the consumption of local mills or in the export of copra cake. During the war the copra producers and the copra mills were zoned in a marriage which was far from happy. Although the prices of copra were based on Zanzibar and the prices fixed for refined and unrefined oil, the coco-nut growers of Tanga and Pangani could still complain that export to Mombasa was more profitable than sale to the local mills and the dhow trade could find profit in smuggling the copra.

The military provided a big market for refined edible coco-nut oil and coco-nuts, and the only modern mill in Tanga was kept working to capacity to supply the demand for oil. No doubt the world in its present chaos will be able to consume all the oil seeds that come on to the market for a number of years and provide adequate remuneration for coco-nut growers, millers and exporters alike. But of all the industries that underwent depression in the thirties, the worst and the longest affected was the copra industry, a catastrophe which it would be well to provide against in the future. Zanzibar, on a two-crop economy, was forced to grapple with the problem as early as 1934 with the introduction of an "Adulteration of Produce Decree", which, despite some difficulties in 1935 [10], enabled the Agricultural Department to record in 1938 [3] that "Tanganyika copra was formerly superior to that of Zanzibar and was imported in large quantities to mix with the latter to improve the quality of our local product. In September, 1938, it became clear that our (Zanzibar) copra had been used to grade up imported inferior Tanganyika Territory produce".

That an Arab member could complain in the Kenya Legislative Council as late as the end of 1945 [7] that nothing whatever had been done agriculturally for the coast, is merely symptomatic of the conditions prevailing throughout the length of the Kenya and Tanganyika [1] coasts for the last thirty years, due largely to the apathy of the grower and the trader. When the Germans were ousted from Tanganyika the coco-nut was a well-established industry, and yet between 1913 and 1939, allowing even for internal consumption by the oil mills, copra production has scarcely doubled itself while the rival industries of cotton and sisal increased fivefold and coffee sixteenfold, the last two by capital investment and legislation, the first by Government control and stimulation.

Lacking leadership the diverse races, African, Arab, Goan, Indian and European, employed in coco-nut growing have never been able to collaborate in formulating a plan for the improvement of the industry on which their livelihood depends, whether cultural, experimental or marketing, and the greatest obstacles to co-operative progress have been put up by the traders, millers and exporters who have made such a good thing out of the copra producer in the last thirty years.

If ever there was a case for a unified service it is in the copra industry of East Africa. The conditions in all the coastal areas are similar, a neglected people and a neglected industry, but with greatest progress in Zanzibar. The countries are interdependent in the copra trade, whether it be a desire to export or the need to keep the mills supplied. And their anxieties are identical. Will the market hold? East Africa could well make itself independent of the world market, for the nutrition experts and the sanitary squads could put a figure to the basic consumption of edible oil and soap required by 13,000,000

inhabitants to maintain adequate standards of nutrition and cleanliness. The starting-off point is mass education and co-operation.

R. de Z. Hall, when District Commissioner of Tanga, held the view that the greatest progress could be made with the coastal coco-nut growers through mass education. The net would require to be thrown wide to embrace the races, African, Arab, Goan, Indian and European, to reconcile the grower and the trader, and to jolt the oldest inhabitants from their grooves and feed the younger generation seeking education and advancement.

Co-operation is an idea no less new to the coastal inhabitant than mass education, but in co-operative marketing, grading, milling and advertising, as well as plantation sanitation and cultural improvement, lies the surest way of developing and co-ordinating the coastal society as cotton and coffee have done for some of the up-country tribes.

Coco-nut Growing on the Tanga Coast

Coco-nut planting has expanded over the past forty years in both the Tanga and Pangani districts and Baker [4] notes in 1934 that "palms are found as far west as Korogwe, but are only a comparatively recent introduction in that area and in Bonde, for when Krapf travelled through Bonde in about 1858 there were no coco-nut palms or fruit trees". "Prior to European occupation, the Digo only planted sufficient palms to supply themselves with palm wine, but the plantations have increased considerably in recent years". This expansion is continuing gradually at the present time, particularly on the inland fringes of the coco-nut belt of Mkinga and Gombero and up the Pangani River along its fertile alluvial banks in place of the old German and Arab sugar-cane plantations. In that area the palms are interplanted with betel nuts and dwarf bananas which command a considerable export trade up the coast to Mombasa. A rough census undertaken in 1940 in the Tanga District (excluding the environs of Tanga township) indicated some 7,500 coco-nut plots owned by Africans alone.

The annual production in the Tanga and Pangani districts, at present prices worth over £50,000 per annum to the grower, is between 3,500 and 4,000 tons of a rather poor quality of copra. In the recent war years, with the large internal demand, both civilian and military, for edible oil and soap, the bulk of this crop has been expelled at the only modern oil mills in Tanga, while an old and small rotary mill at Pangani dealt with a small proportion of the local copra. On occasion imports from Bagamoyo, Dar es Salaam and Mafia have supplemented local production.

There is also an unfathomable consumption and trade in coco-nuts. They have been railed to Kenya for both Mombasa, Nairobi and the military, while the demand in the Northern Province increased considerably during the war owing to the shortage of edible oils, African housewives expelling the oil from the nuts in their own primitive ways. The consumption by the growers of coco-nuts must also be very substantial, probably commensurate with consumption in Zanzibar where [2] "there is a very large but indefinite consumption of nuts for food purposes, estimated as high as one nut per head of the population per day".

Coco-nut Cultivation

It would be idle to refer in this place to the standard practices of coco-nut cultivation as laid down in the textbooks, for few of their precepts are followed on the Tanga coast. Planting is generally closer than the 56 per acre recommended, and in 1943, for the purposes of compensation for coco-nuts removed in the construction of the Tanga aerodrome, the figure of 70 per acre was accepted. Nor is it possible to refer to costs of production, for while the smaller African and Arab growers may be self-contained family units, any figures supplied by the larger growers must always be viewed with a stereoscopic adjustment for claims for an increased price and evasion of income tax. The Government plantations in Tanga and Pangani are leased out and not worked by Government, so that no counterclaim is available to refute or confirm what costings may be submitted.

Coco-nuts are generally planted in annual cultivations, though sometimes in bush. When the annual plantations are abandoned after a year or two, as is the habit under shifting cultivation, bush regenerates and sooner or later the plantations have to withstand the ravages of the annual grass fires. It is common to grow, or to lease the land for growing, cassava and sweet potatoes among established coco-nuts, in which case some sort of bush clearing and cultivation takes place. Near Tanga, cattle are grazed through the plantations, and some attempt is made to keep the bush down, but in most of the coco-nut areas of the Tanga

coast cattle cannot be kept because of tsetse, and even those cattle on the outskirts of Tanga are liable to occasional infection from tsetse filtering in through the bush and thickets.

There is one serious pest of coco-nuts, the Coco-nut Beetle, which breeds in dead and decaying coco-nut trees, logs and stumps, and the Coco-nut Rules, 1922, as revised in 1940, aim at its control as well as improvement in the care of plantations. It will be seen from the above description that the majority of coco-nut plantations are overgrown, and with the burying of coco-nut logs and stumps the Coco-nut Rules are far from effective in controlling the Coco-nut Beetle. The prolonged depression in oil seeds before the war and the subsequent labour shortage for essential war production have been the root causes of this state of affairs. Economy in the employment of labour, both for cultivation and copra preparation has been the order of the day for many years. While the Rules have been applied to the small African grower with fair regularity through the Native Authorities, on the grounds that the small family unit does not incur the expense of hired labour, the Arab, Indian and European plantation owners have harboured behind the shield of inability to pay for labour or unavailability of labour diverted to essential production in the neighbouring sisal industry. Also, while cases for the infringements of the Coco-nut Rules may be taken in the Native Courts, there has never been sufficient staff to attend the Magistrate's Court for days on end in prosecutions against non-natives, particularly the numerous Arabs. But when a large estate has recorded on it 12,000 dead coco-nut trees, logs and stumps all rapidly breeding Coco-nut Beetle, then occupation of the land can no longer be considered beneficial and its subdivision into units capable of maintenance by small holders is called for. The implications of neglect in small holdings will be discussed in the section devoted to land tenure.

The future of the coco-nut industry is in the hands of the small growers, but little progress will be made until every member has a stake in it. Once interest is established, enthusiasm will replace apathy and coercion, while progress will achieve a momentum similar to that of native coffee planting on Kilimanjaro in the thirties. Once the bush is eradicated from the plantations and cleared from outlying thickets and riverbeds, there can develop along with the coco-nuts a flourishing live stock industry, supplying milk to the growers, to Tanga and to the sisal estates, which would readily absorb also the surplus meat supplies. The toil of the grower would then be reduced by the cattle grazing down the grass, while the coco-nuts would get some benefit from manure.

The Tanganyika Copra Bill of 1945, which in the first instance is being applied to Tanga and Pangani, aims to provide for marketing and grading of copra in order to effect its improvement. But once the markets which are being established achieve their objects and stimulate interest in improved copra preparation, the people should be ripe for a co-operative movement which would achieve improved cultivation as well as the handling and, at a later date one hopes, the processing of the crop.

Propaganda for improved cultural practices and copra preparation has not been entirely neglected. Recently a pamphlet, first put out by the Agricultural Department in 1928 in Arabic and Kiswahili, entitled "Coco-nuts and Copra", has been reprinted and distributed. I have been informed that in its early days this pamphlet achieved considerable popularity in the Rufiji, where ambitious scholars used it to learn the Arabic and Roman scripts.

Recordings from a plantation of 500 trees in Tanga, commenced in 1940, have enabled selection of 43 high-yielding coco-nut trees of which 14 each yield annually 80 coco-nuts or over as against the estimated Tanga average of 30 coco-nuts per tree. They possess the desirable characters of freedom from gummosis, thick, heavy copra and large nuts. This has enabled the establishment of a nursery for the propagation of these higher-yielding trees for the replacement of uneconomic trees and for expanded planting.

Tenure of Coco-nut Lands and Registration

At the present time the only district in Tanganyika where the registration of coco-nut plantations occurs is on Mafia Island. This scheme was introduced before the war by a number of administrative and agricultural officers, in particular H. T. Curry, C. B. Garnett, J. V. R. Brown, D. A. G. Dallas and G. S. Brown. Stubbings [11] informs me that all holdings of coco-nuts there are registered, the numbers of bearing and non-bearing trees being entered in a central register and in a notebook carried by the grower, purchased by

himself. The main object of the registration is to reduce the theft of coco-nuts. There are two established markets on Mafia at which copra is auctioned on certain days and the sales of copra are entered by the market-master in the grower's notebook as a check against his number of trees. Unfortunately, no grading of copra is done at these markets before the sale, the main defect in this admirable system. Records rapidly, however, become out of date through the maturation of young trees and the sale of trees. Once in possession of a notebook the owner seldom returns to have his particulars brought up to date, which Stubbings considers becomes necessary every six months. If a system of grading of copra at markets was introduced, he considers that a competent grader at each market could spend his three free days each week checking up the records of plantations.

Such a system, registration of coco-nut plantations combined with marketing and grading of copra, could with great advantage be adopted in other coastal districts as a check on theft, on land tenure, and on the acquisition of land by non-natives, particularly by Arabs foreclosing on indebtedness and mortgages. On the Eastern Province coast Stubbings considers the tendency is the other way, Arab holdings passing more and more into the hands of Africans.

Northcote [9] supports the case for general registration of coco-nut plantations in that, the land being vested in the Crown, he condemns the sale of trees apart from the land, the leasing of the land for the planting of root crops by the owners of fruit and coco-nut trees and the person who claims the right to abandoned trees and land so long as the trees remain alive. He recommends that if a man leaves "trees abandoned for a certain period he would lose his usufructuary right and the land would automatically revert to the Native Authority". "Natives may sell unexhausted improvements through the Native Authority". In the case of coco-nuts their continued abandonment by the Native Authorities, without reallocation, could not be countenanced under the Coco-nut Rules, but the principle that an abandoned plantation should be passed on to a person anxious to bring it back into condition for the sake of the crop would be a marked advance.

There is a strong case, too, for the establishment of an Arab Authority to administer their own affairs and through whom, among other things, plantation sanitation could be controlled.

Coco-nut Theft

The measure adopted in Mafia to counter the theft of coco-nuts by the registration of plantations and the numbers of mature and immature coco-nut palms has already been described, as has the recording of all sales of copra in the grower's pass book. And it has been seen that, combined with grading of copra at markets and a regular check on the plantation records, its adoption in other coco-nut districts could be undertaken with considerable advantage, both as a check to theft and for the purposes of land tenure.

Theft is a very serious cause of loss to coco-nut growers in Tanga and it has the effect also of forcing growers to pick their coco-nuts in an immature condition, long before they are suitable for the manufacture of copra, lest they fail to harvest them at all. This has been counteracted in two ways. In 1941 Government passed the Coco-nut (Theft) Ordinance, which permits the owner of a coco-nut plantation to apprehend any person on his land in suspicious possession of coco-nuts and a policeman to arrest any person carrying coco-nuts who is unable to account for their origin.

In 1942 Government empowered the Native Authorities of the Tanga Province to make orders to control the harvesting of coco-nuts or the making of copra between such dates as might be specified by the Native Authorities. This had the double advantage of checking theft and the picking of immature coco-nuts in that the close season checked the temptation to pick partially ripe coco-nuts and make copra for the sake of a little ready cash. It is possible now to control the manufacture of copra during periods of wet weather. This close season has been extended by the Copra Bill, 1945, to include all coco-nut growers in Tanga Province not in possession of approved kilns.

As a sidelight on how unforeseen factors will influence such a thing as theft, early in 1944, wishing to get some idea of the effectiveness of the above laws on coco-nut theft, the writer asked a Native Authority of Tanga whether coco-nut growers had noticed an appreciable decline in theft. He replied that theft had certainly diminished considerably since the worst of the thieves had been conscripted for the Army!

THE PRINCIPLES OF COPRA MANUFACTURE

As with the plantation sanitation and the cultural methods of the coco-nut grower, the methods of preparation practised on the Tanga coast have little to commend them. But in this case the responsibility lies almost entirely with the traders, millers and exporters. For many years the Agricultural Department has tried to effect improvement in copra manufacture by the encouragement of small drying kilns of the Seychelles type, but every attempt has been foiled by the copra buyers, who have refused to pay a premium for quality. The result has been to discourage the growers from making any attempt to prepare clean, dry copra. While for the manufacture of edible oil, a high grade of copra is desirable, for the manufacture of soap the degree of decomposition of the copra appears to matter little, so there has been little stimulus to the miller to insist on graded copra. Here it may be well to divert shortly to the principles governing copra manufacture.

The greatest weight of copra and the highest percentage of oil are obtained from coco-nuts which are fully brown and ripe, which is also generally the time of natural nut-fall. They are harvested in this condition in Malaya, but in Ceylon and the Malabar Coast of India [6] they generally fall while still partially green, when they are stored for a month or six weeks to mature. The same result is achieved either way. From this condition, if properly dried, a dry, white, brittle copra of the highest quality may be produced. If unripe coco-nuts are picked and the meat extracted and dried, a flabby, elastic copra is produced with low oil content which, because of its elasticity, re-absorbs some oil after being crushed. The residual cake after crushing good copra should contain only 5 per cent of oil, but from immature, elastic and case-hardened copra the oil content of the cake exceeds 7 per cent.

The best copra is sun-dried. Coco-nuts, however, are generally grown in wet, humid climates where the opportunities for adequate sun-drying are limited to certain seasons so that there are considerable periods of the year when sun-dried copra cannot attain the highest quality. It is under these circumstances that kiln-drying becomes a necessary adjunct to the preparation of copra, though great care must be taken to ensure even and not too rapid drying, lest the final product becomes "case-hardened", i.e. the surface of the copra becomes hard and dry, but the interior still remains damp and elastic. This leads to deterioration and shrinkage in storage as well as reabsorption of oil on crushing. Sun-drying takes from five to nine days of sunny weather, kiln-drying can be completed in from one to three days. Preliminary sun-drying may be used to loosen the copra from the shell, drying being completed in the kiln.

The fresh meat of the mature coco-nut contains 45 per cent of water and this must be rapidly reduced below 8 per cent if the copra is not to become mouldy or rancid. Copeland [6] describes good copra as containing from 4 to 6 per cent water and 65 per cent oil. In the modern crushing plant at Tanga, the local copra is said to yield 60 per cent of crude oil or 40 per cent of refined oil. Moulds develop on the exposed damp surface of copra and, should rain fall on the copra during drying, or green copra be stored in heaps, moulds of various colours develop which can ultimately reduce the copra to a slimy oily mess. With rapid drying the moulds drop off and cause no damage. Acidity develops from the hydrolysis of free fatty acids in deteriorating copra and renders the purification of the oil difficult. The quality of the copra for the production of crude oil matters little, but the higher the quality the greater the oil content and the less refining required. The residual coco-nut cake from bad copra after the extraction of the oil loses much of its nutritional value, particularly in proteins and carbohydrates. Another factor which must be watched in the preparation of copra is the exclusion of dirt, sand, and foreign matter, which cause rapid depreciation of crushing machinery.

A dry, clean, well ventilated building with a hard floor or a stand is necessary for the storage of copra. An insect pest common in stored copra in Tanga, the red-legged ham beetle *Necrobia rufipes*, is described by Harris [8] as "a cosmopolitan species attacking cured meats, old cheeses, hides, Egyptian mummies, palm nut kernels and guano in addition to copra. The life history from egg to adult is passed in from 30 to 36 days during warm weather. The female beetle has a long life and may lay up to 1,000 eggs. Under suitable conditions a heavy infestation may be built up rapidly, with considerable damage to the substance attacked. Copra appears to be generally attacked in the tropics, especially copra which is damp and mouldy. Copra from old nuts is stated to be practically immune. Attack will cause loss in weight as well as in appearance. Like other stored products, copra

requires such elementary precautions as cleaning of stores. Fumigation under tarpaulins with carbon bisulphide would arrest an infestation".

Cook [5] advises that clean, freshly prepared copra should be placed in clean, close-woven bags immediately after drying, which should be closed to prevent ingress of insects. These bags should be stored in clean, dry, rain-proof stores which allow free air movement round each bag.

Copra Manufacture on the Tanga Coast

Coco-nuts which are not sold to Tanga for local consumption or for export upcountry to the Northern Province and Kenya, or consumed by the grower and his dependants, are manufactured into copra.

The small grower, whether African or Arab, is always short of ready cash, and this, combined with the apathy attributed to the coastal climate, leads him to sell his copra as soon as possible after extraction in an improperly dried condition. Such is the hurry to sell copra that on occasion the writer has seen it brought in to the mill for sale within 24 hours of extraction from the coco-nut. Until 1944 copra was manufactured at any season, irrespective of weather conditions. Thereafter the Native Authority rules enforcing a close season were made to coincide with the rainy periods so injurious to the manufacture of copra.

During the picking season the grower extracts the nut from the husk, breaks the nut in half and exposes the two halves on the ground to dry. As it shrinks away from the nut, he extracts the copra and continues to dry it on the ground until, in his opinion, it is fit to market. No special mats, stands or drying trays are used and the copra more often than not contributes its share of sand to the ruination of the extracting machinery. While the enforcement of the close season has greatly raised the proportion of mature nuts picked, there is always a proportion of immature nuts in the pile which produce the rubbery copra. This is mixed in with the mature copra for sale and no attempt at sorting by the grower at this stage takes place. The rapid and only partial drying, particularly of immature nuts, leads to rapid deterioration of the copra in bulk. The methods employed in storage by traders and millers tend to encourage this. A great improvement could be effected if the grower could be persuaded to store his nuts for a month or two before extraction.

In 1944 one of the Tanga millers had agreed to voluntary grading of copra as it was brought to the godown for sale, with a view to improving the quality of copra brought in and educationally as a prelude to the Copra Bill, 1945. However, having bought and paid for the copra by grades, this miller then bulked all the grades together in his godowns despite the fact that they were suitably partitioned off and he could have stored the grades separately.

The establishment of markets in the Tanga and Pangani districts with grading of copra before sale and rejection of under-grade samples will, if backed by drying and storing regulations, rapidly cause an improvement in the preparation of copra by the growers. Once a grade of reasonable quality is established, traders and millers alike will be able to raise the price of copra to nearer its true value. It has been pointed out earlier that the principal obstacle to improvement in the past has been the refusal of the trader to pay a premium for an improved quality of copra. Persistence in this might well hasten a co-operative movement among growers to market their crop in bulk and, ultimately, perhaps, to process it themselves. The final step in such an evolution would be a health compaign conducted throughout East Africa by the copra producers to encourage the consumption of coco-nut oil and the greater use of soap.

One of the difficulties which have prevented grading of copra has been due to the numerous coastal ports at which copra has been shipped. By the establishment of markets and by the increasing proportion of copra which is being crushed locally, inspection of copra on arrival at the market and mill is rendered easier. No industry develops without making some contribution to its welfare and a levy of ten cents per frasila (35 lb.) equivalent to Sh. 6/25 per ton on all copra graded would pay for grading and instructional staff and amply repay the grower by the improvement in quality and value of his product.

Conclusion

The suggestions that the improvement of the copra industry, a start with which is being made on the Tanga coast under the Copra Bill, 1945, by control of cultivation, preparation, marketing, processing and sale under a unified service for East Africa, by registration of plantation and coco-nut trees, by mass education and co-operation and by the enforcement of grading at markets and drying

and storing regulations may savour of regimentation. Co-operation is essentially a subordination of the individual for the good of the community to the ultimate benefit of the individual. The Kilimanjaro native coffee crop has thrived on regulation of cultivation and co-operative marketing, the Bukoba coffee industry was saved from extinction in the early thirties by compulsory grading, while the cotton plant is nursed from the cradle to the grave by the Cotton Ordinance with great advantage to the cotton grower. The copra industry alone of the big agricultural ventures has lacked a fairy godmother to organize her existence.

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GRASSES AND OTHER HERBS AND LEY FARMING

As a result of the ever-growing attention that is being given to grassland problems by agricultural scientists, a British Grassland Society has been formed with Sir R. George Stapledon, C.B.E., M.A., F.R.S., the father of modern grassland research, as its first president.

The inaugural meeting of the Society was held on 20th to 22nd June last year at the Grassland Improvement Station, Drayton Manor, Stratford-on-Avon. This was followed by tours of Colesborne, which was until recently, the Cotswold sub-station of the Grassland Improvement Station, and a tour of the Leicestershire grasslands. This latter ended at Medbourne where members were shown the famous Mill Field, world renowned as a bullock-feeding pasture with an outstanding performance. In a normal season it will probably produce 3–4 cwt. live weight increase per acre. It may in exceptional seasons, even produce up to 6 cwt. live weight increase per acre. The field is now being compared with a new ley of a mixture of rye-grass and clover, direct sown in 1944 after three war-time arable crops.

The Society "born of grassland, wedded to grassland and which aspires to be the parent of great advances in the technique of the full exploitation of 'grass'" has now launched a periodical under the title *Journal of the British Grassland Society*, the first number of which appeared in March, 1945.

For the year 1945–1946 two numbers are to appear at a subscription rate of Sh. 10. The Editor is Dr. H. I. Moore, Department of Agriculture, The University, Leeds.

The first number contains 88 pages, six of which are given over to a list of members of the Society with their addresses. There is a foreword by Sir R. George Stapledon, and it contains the following papers:—

"The Output of Pasture and its Measurement" by P. A. Linehan and J. Lowe. "The Role of Silage in Grassland Management" by S. J. Watson. "Observation of the Occurrence of Leatherjackets (*Tipula paludosa* Meigen) on Re-seeded grassland in Yorkshire" by H. W. Thomson. "The Productivity of Reclaimed Upland Areas in Montgomeryshire" by W. Ellison. There is also a report of the first meeting of the Society with the presidential address.

The papers are well illustrated by photographs, line drawings and text figures and the printing is clear and easy to read.

The Journal should be of value to all those research workers in the Colonial Empire engaged in the science of grassland management and its problems and to those abroad who practice mixed farming. It will keep them in touch with the latest developments and techniques in the United Kingdom in the management of the modern system of ley farming.

P. J. G.

PHOSPHATE DEPOSITS IN TANGANYIKA TERRITORY

With Special Reference to the Zizi Apatite-Limestone, South of Kisaki

By G. M. Stockley, D.I.C., A.R.C.Sc., A.R.I.C., F.G.S., Geologist, Lands and Mines Department, Tanganyika Territory

(*Received for publication on 23rd July, 1946*)

No rock phosphate (phosphorite) has as yet been found in Tanganyika Territory; the nearest examples are some locally phosphatized limestone underlying bat guano deposits in certain limestone caves. Teal and Oates (1933), for instance, in a paper published in the *Journal of the Kenya and Uganda Natural History Society*, describe such an occurrence from the Southern Highlands Province as follows: "A large hill of chemically formed 'secondary' limestone, forming part of the wall of the Songwe River gorge and derived most probably from adjacent marble of the Lower Basement Complex (Basement System), is riddled with solution cavities, forming a connected chain of caves. The deposit varies from the fresh, dark, most highly organic dung at surface to a cream-coloured, friable, calciferous and phosphatic material found at 16 to 20 ft. depth." This material was worked over the decade, 1934 to 1944, and some 1,100 long tons were sold, commanding a price of Sh. 60 per ton, falling to Sh. 45 per ton.

Similar deposits are known from the Jurassic caves at Amboni near Tanga and also from the Jurassic caves near Kipatimu Mission in Kilwa District. A brief account of the latter is given by the writer (1943), who shows that the floor of the main cave (the Nangoma Cave) measures 170 yards long and a width of 70 yards. This floor is covered with a soft layer of bat guano.

A deposit of phosphatized limestone is known on Latham Island south of Zanzibar and about 44 miles east-south-east of Dar es Salaam; this deposit was described by L. P. Lane in *Tanganyika Notes and Records* (1944). He describes the island as a "plateau composed of phosphatic limestone formed through alteration of the original coral by downward percolation of guano aided by atmospheric water. The rock is oolitic in form, grains of unaltered coral being cemented with calcium phosphate, and it is covered with a varying thickness of guano, estimated at 3,500 tons. The southern end of the plateau is slightly lower and there the cliff is crumbling on to the reef; its average height of 10 ft. was confirmed". From the dimensions given by the author it is evident that there are some 190,000 long tons of low-grade rock phosphate for the 10 ft. of the island plateau. Analysis of rocks below high water mark averaged 8.8 per cent P_2O_5 or 19.2 per cent tricalcium phosphate and another group taken from above sea level averaged 8 per cent P_2O_5 or 17.5 per cent tricalcium phosphate. By sieving it was possible to improve the phosphoric acid content up to 21.6 per cent P_2O_5, eliminating hard particles.*

In Tanganyika, mineral phosphate rock or apatite-bearing rock has been recorded from three localities, one by Teale (1922) in the Mpwapwa-Tubugwe area, where small crystals of apatite were found embedded in a yellowish-brown opalline silicious rock; and the other two by the writer (1931), the one as occasional large bluish apatite crystals in crystalline limestone from Nagaga (between Newala and Masasi) and the other (1931) of an apatite-crystalline near Zizi, south of Kisaki, south of the Uluguru mountains in Morogoro District. This article is designed to give fuller information about this last deposit for it is, as far as we know at the present moment, the only occurrence which has any potentiality as a source of a phosphatic fertilizer.

Situation

The Zizi occurrence was discovered by the writer in 1931 during a reconnaissance traverse in the Kisaki-Rufiji region. The apatite-limestone is situated above the confluence of the Ruaha and Rufiji rivers, approximately 30 miles south of Kisaki, located west of the Mkoalanda stream close to its junction with the Ruaha. The deposit lies between the altitudes of 625 and 525 feet above sea level.

The terminus of the nearest road is at Kisaki, 78 miles from Mikese Station on the Central Railway; a route shorter by 14 miles is

* Acknowledgments are due to A. G. Doyle, A.I.M.M., of the East African Engineering and Trading Company, Limited, Dar es Salaam, for permission to publish these figures.

possible from Kisaki via Mvuha and Tununguo to Ngerengere Station. This shorter route would total less than 100 miles. Full details of the relative advantages of various routes and the nature of the country are preserved in the records of the Geological Division at Dodoma.

Description of the Zizi Apatite Limestone Occurrence

The deposit is situated on a small ridge sloping down into the Mkoalanda stream and is 0.75 miles from the Ruaha River. The attached map was compiled from observations made by measuring wheel and indian clinometer, directions were obtained by prismatic compass.

The apatite-limestone is a narrow, long lenticular raft lying within the gneisses of the Basement System. The prevailing direction of the strike is 110° (magnetic bearing), although the actual trend of the limestone swings a little in small open waves. The dip is vertical, so that the outcrop cuts across the Mkoalanda stream in a straight line. There is no evidence of any change in this dip angle, although the attitude of many of the outcrops might seem to suggest it. This apparent attitude is due partly to solution of the limestone along the stratigraphic planes and partly to the slight dislocation along horizontal joint planes due to gravity.

The width of the limestone is about 110 ft. About 400 ft. west of the Mkoalanda River, following along the strike, the width of the limestone might be as much as 135 ft., but unexposed rock on both walls accounts for nearly half of this figure. The central and northern portion, about 72 ft. wide, consists largely of weathered strips of apatite-limestone.

Further west there is a gap for nearly 650 ft., where exposures are wanting; but about 1,000 ft. from the Mkoalanda stream a continuous outcrop is seen for a further 2,500 ft., where widths of massive rock 10 to 30 ft. are not uncommon. It is in this area that the apatite is most markedly uniformly distributed and concentrated.

The effective length of the limestone is measured as 3,700 ft., average width is 110 ft., and on these data, allowing a deduction of about 30 per cent for inclusions of extraneous rocks such as pegmatites and selvages of mica and vermiculite, are based the estimate of 2,000,000 tons of the apatite-limestone for every 100 ft. in depth.

A study of the gneisses in this region shows that the limits of the apatite-limestone are due to metamorphic influences which these rocks have undergone. Under certain conditions rocks may be converted from sedimentary formations into a variety of gneisses. Thus a limestone may be changed into a metamorphic rock such as a calcareous gneiss; and an apatite-limestone such as that at Zizi, if metamorphosed, would lose its original minerals and thus become useless as a source of phosphatic material.

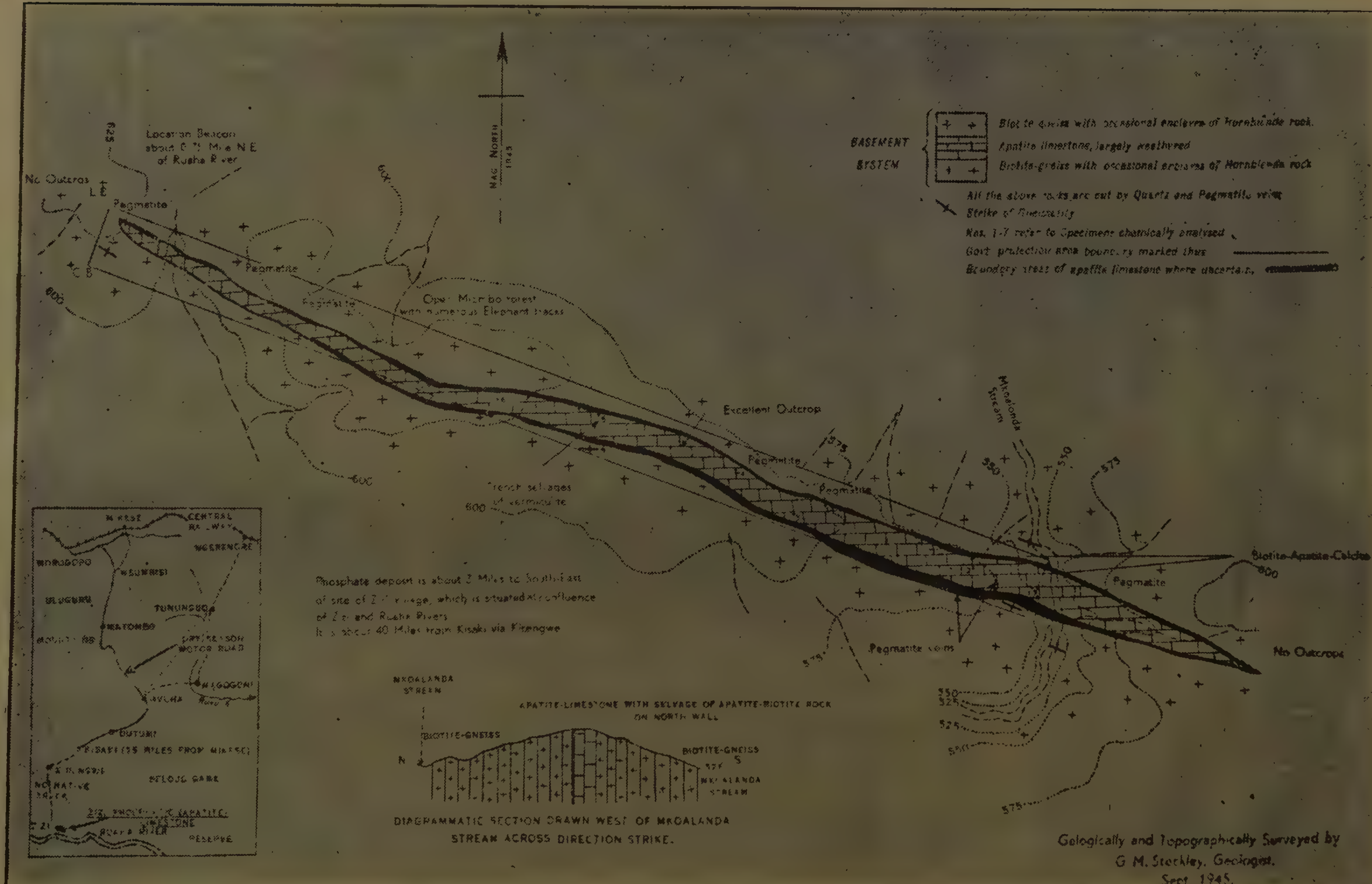
Owing to the fact that the majority of the rocks of the Basement System have undergone varying degrees of metamorphism, it is not advisable to conclude that the apatite-limestone may continue to great depths. There is always the possibility that the metamorphic effects may have penetrated deeply into the limestone, and it will be necessary to prove the actual dimensions of the apatite-limestone raft by either sinking shafts at suitable intervals or, if large-scale exploitation is contemplated, by diamond drilling to a depth of 1,000 ft. or more.

Chemical and Ore-dressing Report

Chemical analyses were carried out by A. Caperle, Assistant Metallurgist in the Geological Division, on seven samples of rock collected by the author. These samples were taken at the numbered points marked on the geological map, spaced more or less evenly in the main portion of the deposit. These analyses show that the rock varies from 3 to 10 per cent phosphoric oxide or 7.22 per cent tricalcium phosphate—an eighth and bulk sample yielded 7.28 per cent P_2O_5 and thus the rock must be considered a low-grade apatite limestone.

Mineral dressing tests were carried out by J. H. Harris, Metallurgist to the Geological Division at Dodoma. These experiments were designed primarily to concentrate the apatite and thus produce a higher grade product. He states in his report " as regards concentration methods, flotation was ruled out for the present as being too expensive to install and operate, at any rate in the early stages of any possible development of the deposit. There remained the possibility of gravity concentration, either by shaking tables or heavy-medium separation. The latter being a second choice owing to the predominance of small grain sizes, no tests were carried out at this stage. A further method . . . . involved calcining the stone, slaking and then screening the apatite crystals from the pulverulent slaked lime".

ZIZI PHOSPHATIC (APATITE) LIMESTONE, RUAHA RIVER, SOUTH OF KISAKI, MOROGORO DISTRICT



SCALE 1 : 5,000. Contours every 25 feet.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
	%	%	%	%	%	%	%
SiO2	1·72	2·35	2·99	1·87	1·08	5·01	0·17
Fe2O3 ..	3·08	3·99	2·28	2·48	2·23	3·88	1·95
Al2O3	1·56	2·01	1·08	0·64	0·73	2·00	0·24
Mn3O ..	0·63	0·41	0·68	0·69	0·59	0·49	0·84
CaO	48·32	48·26	49·30	49·76	46·24	45·10	49·23
MgO	1·40	1·23	1·23	1·56	2·75	1·70	3·70
P2O5	10·41	4·45	6·22	5·90	10·57	7·65	3·15
F(Calc.) ..	0·92	0·40	0·55	0·52	0·94	0·68	0·28
Loss on ignition	31·70	36·44	34·86	35·34	30·92	29·68	40·40
	99·74	99·54	99·19	98·76	96·05	96·19	99·76

CALCULATED COMPOSITION OF ROCK ANALYSIS No. 1

	%
Apatite (CA5FP3O)	24·6
Calcium carbonate (CaCo3) ..	60·9
Magnesium carbonate (MgCO3)	2·93
Iron Carbonate (FeCO3) ..	4·59
Unallocated oxides—	
Silica (SiO2)	1·72
Alumina (Al203)	1·56
Manganese Oxide (Mn304) ..	0·63
	96·93

As a result of these tests it was found that by gravity concentration on a Wilfley table 47.1 per cent of the total P_2O_5 content of the rock was recovered in a concentrate 13.64 per cent by weight of the feed. The total P_2O_5 content of the concentrate was 25.02 per cent, equivalent to 54.66 per cent tricalcium phosphate. By the alternative method of first calcining the rock, slaking, sieving and washing, "the concentrate, while no higher in total P_2O_5 content than the gravity concentrate, represented a recovery of 83.1 per cent of total P_2O_5 in the rock and was 27.25 per cent by weight of the feed".

No experiments on the treatment of the apatite concentrate in order to improve its citric acid solubility have as yet been done; but it is already known that this can be done; effected either by calcination with added silica in a current of steam at 1,400°C to produce a soluble silicophosphate.

Economic Possibilities

Chemical analyses of the apatite-limestone vary between 3.15 per cent and 10.57 per cent P_2O_5 (or 6.85 per cent and 22.37 per cent $Ca_3(PO_4)_2$) and these figures show that as it exists the rock is a low-grade phosphate limestone and unable to be of much use for agricultural purposes without beneficiation. In the trade, according to Bulletin of Imperial Mineral Resources Bureau (1921) p. 6 "phosphate rock should contain at least 40 per cent of tricalcium phosphate for the successful manufacture of superphosphate; second-grade superphosphate is usually required to contain from 50 to 60 per cent tricalcium phosphate. First-grade phosphate rock may carry as much as 90 per cent tricalcium phosphate, as is the case with many of the Pacific deposits, but all phosphate rock carrying from 60 to 80 per cent tricalcium phosphate may be classed as high or first-grade rock. The objectionable impurities in rock phosphate are iron oxide and alumina, which cause superphosphate to revert and become insoluble. Phosphates are therefore usually sold under a guarantee that they do not contain more than 4 per cent of those impurities. A small amount of calcium carbonate is beneficial, but fluorine, if present in considerable quantity, is objectionable".

In the Tanganyika rock the analyses show that the impurities keep within these figures. Beneficiation has enabled the product to be increased to over 55 per cent tricalcium phosphate, which would place it among second-grade phosphate rock. In addition to this, however, the phosphoric acid must be made available to the plant and this can only be done by the material undergoing a further

process. In Kenya a process has been devised involving calcination with Magadi ash to produce a silicophosphate highly soluble in citric acid. The degree of solubility in citric acid is a measure of the degree of availability of phosphoric acid to the plant. Obviously every additional process incurs additional costs, and higher costs lower the competitive value of the final product. It seems to the writer that in the first case possibilities of fine-grinding the beneficiated product (55 per cent tricalcium phosphate) and its application direct as a fertilizer should be fully explored.

According to E. M. Crowther (1936): "Phosphate with fluorine equal to or greater than the fluorapatite equivalent may be improved in solubility by calcination at 1,400°C in the presence of 5-10 per cent silica and steam. No increase in citrate solubility occurs until the fluorine in excess of the fluorapatite equivalent has been removed; afterwards the increase is proportional to the loss of fluorine. It was found in pot experiments that such calcined phosphates with more than 78 per cent of their phosphoric acid citrate-soluble were as effective as superphosphate". It seems, therefore, that experiments should be carried along these lines, primarily to decrease the costs of manufacture and also to increase the grade of the phosphoric acid availability until an economic grade is attained.

In conjunction with J. H. Harris, the writer has roughly worked out the costs of each type of product landed at Ngerengere station based on milling 25 tons per day. They may be estimated thus:—

A.—Low-grade cheap phosphatic "unburned agricultural lime". Merely crushed rock—

	Sh. per ton
(1) Mining opencast; Sh. 5 per ton	5
(2) Milling—fine grinding of rock to 100 mesh	6
(3) Transport, 100 miles	35
Total ..	46*

B.—Second-grade phosphate rock: low citric solubility. Produced by gravity concentration—

	Sh. per ton
(1) Mining, opencast, Sh. 5 × 7.5 ..	37/50
(2) 30 mesh grinding, concentrating on Wilfley table and re-grinding of concentrate to 100 mesh ..	30
(3) Transport, 100 miles	35
Total ..	102/50*

Recovery 3-3.25 tons/day or 13-14 per cent.

C.—Second-grade phosphate rock: low citric solubility. Produced by calcining the rock, then slaking, sieving and grinding to 100 mesh—

	Sh. per ton
(1) Mining, opencast, Sh. 5 × 4 ..	20
(2) Calcining, etc.	20
(3) Transport, 100 miles	35
Total ..	75*

Recovery greater than *B*: probably about 27-28 per cent.

D.—High-grade Fertilizer. Produced by calcining *C* with Magadi soda (Na_2CO_3) to produce sodium phosphate—

	Sh. per ton
(1) Mining, opencast, Sh. 6 × 4 ..	24
(2) Concentrate the apatite by calcining	20
(3) Calcining with soda	150
(4) Transport, 100 miles	35
Total ..	229*

E.—High-grade silicophosphate fertilizer. Produced by calcining *C* with silica and steam at high temperature—

	Sh. per ton
(1) Mining, opencast, Sh. 5 × 4 ..	20
(2) Concentrating the apatite by calcining	20
(3) Calcining in steam at high temperature	40
(4) Transport, 100 miles	35
Total ..	115*

Recovery about 30 per cent.

* If there is no return payload the cost of transport is increased from Sh. 35 to Sh. 55 and the cost per ton of each product by Sh. 20.

It is evident that either A, C or E are the most practicable products. The writer has no information as to the advisability of using the low-grade cheap phosphatic "unburned agricultural lime". The product C might be used in conjunction with either E or with the Uganda silicophosphate, using the latter as a first dressing. Superphosphate landed at Dar es Salaam costs about Sh. 170 per ton; it would, therefore, be necessary to reduce the costs of the high-grade silicophosphate product to compete even more satisfactorily with imported phosphatic fertilizers. The writer is informed that it is agricultural practice to apply superphosphate as a first dressing and to follow up with finely ground mineral phosphate, which is much more slowly absorbed into the soil and only thus gradually becomes available to the plant.

The chairman of the East African Industrial Research Board has kindly supplied the writer with the provisional estimates of costs of producing silicophosphate in combined mining and silicophosphate plant at Busumbu, Uganda. The capital outlay is estimated at either £220,000 or £250,000, according to the plant capacity. With an annual capacity of 30,000 tons the cost per ton of fertilizer is estimated at: 25 per cent citric soluble P_2O_5, Sh. 105 to Sh. 109; 15-17 per cent citric soluble P_2O_5, Sh. 65 to Sh. 71. After doubling the capacity of the plant cost per ton of fertilizer would fall to about: 25 per cent citric soluble P_2O_5, Sh. 92; 15 per cent citric soluble P_2O_5, Sh. 55.

These figures are comparable with those worked out on general data by J. H. Harris and the writer for the Zizi deposit. In either case these figures must be considered as merely preliminary guesses at the probable actual working costs.

Phosphatic Fertilizers

As a plant food, phosphoric acid fulfils the following important functions: —

(1) It encourages the root formation of plants, especially in the very early stage of development.

(2) It hastens ripening.

(3) It increases the proportion of fruit to plant and, in particular, weight of grain to weight of straw.

(4) It is essential for plants to form chlorophyll.

(5) It increases the population of soil bacteria.

(6) It may also nullify certain toxic elements in the soil, such as excess salts of iron and aluminium.

(7) It is vital to the health of animals that the crops they eat, whether grass or roots, should contain a sufficiency of this important element in order that healthy bones and teeth may be formed.

The quantitative effect of the application of phosphatic fertilizers to East African soils has not yet been demonstrated, although there is no doubt that many of the East African soils do respond very much to the application of phosphatic fertilizers. Experiments in all three territories are actually in hand. The writer has had the privilege of reading the notes on a recent meeting (20.3.46) of the East African agricultural and scientific authorities, at which the subject of field experiments with silicophosphate was discussed. They state: "A discussion took place on the evidence now available on the value of phosphate manuring in East Africa, and on the probable time required to produce sufficient evidence for a decision on the need for a large-scale calcining plant. The Kenya representatives pointed out that their pot tests and small plot experiments with silicophosphate had shown it to be at least as effective as superphosphate, and that it should be preferable to superphosphate on acid soils as there would be less wastage through fixation by iron and aluminium. Wheat in Kenya would be uneconomic without applications of superphosphate and the wartime annual imports of 7,000 tons of superphosphate could immediately be replaced by silicophosphate. Rock phosphate did not appear to give striking results, but its slower solubility indicated that it might be usefully applied during the grass ley period. Even where phosphate did not show much benefit alone, it must be kept in mind that experiments in Uganda had shown that nitrogen as well as phosphate was required".

Recommendations

It has been shown that the Zizi apatite-limestone has certain potentialities as a source of phosphoric acid for use as a fertilizer; but before any serious large-scale exploitation is contemplated it will be necessary to make certain preliminary investigations. The situation of the deposit one hundred miles south of the Central Railway places it at a definite disadvantage and there is no way of circumventing this handicap without both encouraging agricultural development in the immediate neighbourhood and cheapening the cost of

production of a high-grade product. The investigations, which should be completed before any work is undertaken, may be briefly enumerated as follows:—

(1) At least one small shaft should be sunk to 100 ft. in the centre of the deposit, to be followed by two others at the north-west and south-eastern ends. This should give the necessary data for the proof of the existence of two million tons of rock. For large-scale exploitation at least one borehole should be diamond-drilled into the centre of the deposit, in order to prove that the apatite-limestone continues in depth. It may be necessary to drill two more hiles, placed north-west and south-east 1,000 ft. to the east and west of the first hole respectively and directed slightly inclined inwards to the deposit in order to strike the phosphatic rock at 1,000 ft. in depth. The data gained from the first hole should indicate if further holes are required. The data derived should give a fairly precise estimate of the actual size of the deposit.

(2) As soon as the boreholes have been drilled and the dimensions of the apatite-limestone determined, certain topographic surveys should be undertaken to include the following areas:—

(*a*) North side of the Ruaha River down-stream to the Rufiji and to include the Pangani Rapids; distance about 35-40 miles. The object of this survey should be to determine the possibilities of producing power by hydro-electric means. Accurate measurements of the fall of the rapid at (old) Vikindu and of the Pangani Rapids of the Rufiji River would be made. Measurements by aneroid by the writer indicate a fall of 30 feet at Vikindu over a distance of two miles, and a fall of 50 feet at Pangani Rapids over a distance of 400 yards. The volume of the Ruaha River at Kidatu Bridge, south of Kidodi, in September, 1945, was estimated at 3,000 cusecs, and the Rufiji River at Rupiras, above the Shuguli Rapids, in October, 1931, measured 3,400 cusecs.

(*b*) A strip of country about 100 miles long by 10 miles wide, from the Zizi deposit northwards to Kisaki, thence to Ngerengere via Tununguo, with a view to locating the best road and Decauville track alignment.

(*c*) Upstream from the Zizi deposit to the Kilosa-Ifakara road—a distance of 40-50 miles. This survey would be designed to connect with the Kiberege-Kilombero agricultural region. The writer is informed by the Director of Agricultural Production, Tanganyika, that "there is some possibility of the development of sugar cultivation on a large scale in certain areas of Tanganyika and if that took place there might be some demand for phosphatic fertilizers".

(3) Experimental work on producing a high-grade citric acid soluble product by the cheapest method should be continued to a successful and final issue. Inquiry also should be made on the possibility of erecting a nitrogen-fixation nitrogenous phosphatic fertilizer.

Conclusions

Tanganyika has a potential source of a phosphatic fertilizer in the Zizi apatite-limestone, but more information is required for large-scale exploitation about rock continuing in depth, and experimentation should be undertaken in order to improve the citric acid solubility and also to decrease the costs of production. Two million tons of rock in the first hundred feet of depth may be considered a fair estimate of the rock available, and thus this should yield 500,000 tons of a high-grade phosphatic fertilizer. At the moment and for some time to come it is unlikely that Tanganyika will absorb more than 5,000 tons annually even after extensive propaganda. A 25-ton a day mill in the first case would cope with most requirements. Field experiments should be carried out to test the effectiveness of the low-grade, cheap phosphatic "unburned agricultural lime" and the finely ground second-grade phosphate rock with low citric acid solubility. Most soils in Tanganyika are deficient of both lime and phosphoric oxide.

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SELECTION AND IMPROVEMENT OF FOOD PLANTS IN RELATION TO BETTER NUTRITION*

By A. Glendon Hill, Director, East African Agricultural Research Institute

The selection and improvement of colonial food plants by plant-breeding should be an essential part of any general plan for bettering the nutrition of indigenous colonial peoples. Unfortunately, this has not been generally recognized in the past. Where plant-breeding has been provided for in our tropical dependencies, the work has usually been directed towards improving cash crops, such as cotton, probably because of the more immediate results which could be expected in the form of increased revenue. In those colonies where provision has been made for the scientific study of native food crops, the investigations have often been aimed at the direct attack on plant diseases and pests. There is little doubt that had our colonies spent more in the past on the indirect method of attacking plant pests and diseases through the medium of plant-breeding, the health of the food crops and the standard of nutrition amongst our colonial peoples would be considerably higher than it is to-day. In support of this contention one could point out that the plant pathologist not infrequently has to become a plant-breeder himself eventually in order to solve his disease problems, the breeding of resistant strains often being more satisfactory than direct methods of attack, particularly when dealing with the crops of primitive farming communities.

One of the main reasons for the comparative neglect of plant-breeding in the past has been the belief that the improvement of native farming methods should have priority over the improvement of crop varieties by plant-breeding. There is much to be said for this point of view, but in my opinion neither method should be pursued alone; both must be carried out concurrently whenever possible.

When setting out to improve the food crops of primitive indigenous peoples, plant-breeding should be embarked upon as early as possible since it is the only scientific method whereby it is possible to bring about increased crop yields per acre without, at the same time, changing agricultural methods, or making greater demands on the strength, ability or skill of the farmer. If only because of this fact, it is a mistake to postpone plant-breeding until the general standard of farming in the country has improved. I would make one proviso, however, it is essential to have a proper channel for the dissemination of the improved varieties. It is little use producing better crop varieties unless adequate machinery exists for distributing these varieties to native farmers and persuading them to make use of these by demonstrating their advantages. In primitive communities Government agencies must undertake this function of seed distribution, otherwise the work of the plant-breeder is largely wasted.

Yet another reason for the comparative backward state of native food crop improvement in our colonies, has been the lack of trained plant-breeders. All too often the work of food-crop improvement has had to be left to already over-burdened agricultural officers who, in any case, are usually unable to carry out such work properly owing to the large amount of their time spent in travelling. In East Africa an agricultural officer is not infrequently absent from his headquarters for half of each month, with the result that he cannot give the necessary time to plant-breeding, which is an exacting, whole-time occupation when properly carried out.

It is not generally realized what a vast and promising field awaits the scientific plant-breeder in many of our colonies, particularly in Africa. The food crops of the ancient civilizations of Europe and Asia have undergone improvement by highly successful empirical methods extending over centuries, but in the case of the food plants of tropical Africa, a region which only recently emerged from a state of constant intertribal wars and migrations, the process of crop improvement is still in the primitive stage. For this reason it should be comparatively easy to achieve a very substantial increase in food crop yields in a relatively short time by simple selection methods alone, without resorting to long-term breeding based on genetics. In Europe and North America private individuals and seed merchants were the first to undertake the sorting out and improvement of crop varieties, using farmers' mixtures as their raw material, and very great improvement were made in this way through selection alone, even before anything was known about the laws of in-

* Being the substance of a paper read before the Royal Society's Empire Scientific Conference at Oxford, July, 1946.

heritance. However, we cannot expect private individuals or firms to perform this function in our tropical dependencies where there is no market for seed amongst native farmers and for this reason the work must be undertaken by Government departments.

Notable progress has already been made by the agricultural departments in some of our colonies with the improvement of certain cash crops, such as sugar-cane, cotton, coffee and wheat; but this it not enough. In future we must give equal consideration to the improvement of the common native food crops, and make provision for the setting up of plant-breeding stations solely for these crops. The shortage of plant-breeders rather than shortage of funds is likely to prove the main hindrance to progress.

From what I have said it might be supposed that I considered the task of the plant-breeder in the tropics was a comparatively easy one. This is not so. Apart from the difficulty of working in extreme heat, often with unskilled and illiterate helpers, the plant-breeder in the tropics finds himself up against all sorts of difficult problems, some of them the result of the environment, others man-made. Two problems in my own experience will illustrate my point. In Northern Nigeria, where sorghum millets are the major crop, it was found that selected strains which gave increased yields in their own district appeared to be incapable of competing with unimproved local varieties when grown elsewhere, even if only a few miles away, thus indicating a degree of local adaptability amongst sorghum varieties which completely upsets the plant-breeder's calculations. The second example comes from East Africa where in the case of cassava selected for resistance to virus disease it has been found that clones which are resistant in north-east Tanganyika may prove highly susceptible when grown elsewhere in East Africa, thus making it necessary to carry out selection for virus-resistance in each of the main cassava-growing areas.

When setting out to improve the nutrition of a primitive agricultural community the initial inquiries should, I think, be drawn up on comparatively simple lines, and should not be allowed to become too diffuse. In the first instance inquiries should, I consider, be confined to two vital questions, i.e. what are the main deficiencies in the local diet and how can these be best overcome. On the answer to these two questions will depend the nature of the plant-breeding programme to be undertaken in each territory.

In drawing up a plant-breeding programme we have to decide at an early stage whether to aim at improving quality as well as quantity. Personally, I am of the opinion that when dealing with the native food crops of a primitive community, the plant-breeder should first aim at securing the largest and healthiest crops per acre and should not concern himself with attempting to alter their composition, except in regard to carotene content in, say, maize and sweet potatoes where, other things being equal, yellow varieties are to be preferred. Assuming that eating and keeping qualities are satisfactory, the best crop varieties for the native farmer producing his own food are those which give the greatest yield per acre. The main consideration, I believe, is food value per acre and not food value per ton of produce. Where the local diet is scanty and ill-balanced, as it is in many parts of the tropics, no amount of improvement in quality is going to convert such a diet into a full and well-balanced one. It will be time enough therefore to attempt improvements in the composition of food crops when the problem of supplying the necessary bulk and variation in diet has been achieved.

The war having ended, plans are now being drawn up for the reorganization of scientific research in our tropical dependencies, and it is therefore appropriate to consider what form our future plant-breeding programmes should take. Some of our dependencies contain a vast number of crop varieties, most of them mixed, about which very little is known. Therefore, one of the first items in a plant-breeding programme should be a survey of the native crop varieties in each territory. These should be collected, sorted out, and tested under a wide range of conditions—the best being selected for further trials. When the possibilities of improving these crops by ordinary selection methods have been exhausted, then crossing should be exploited. Apart from breeding work the programme should make provision for the importation, through quarantine, of promising new varieties as well as wild forms for use as breeding material.

In any plant-breeding programme designed for our African colonies special attention should be directed to the production of short-term millets and maize suitable for the semi-arid zones where little can be grown at present. Great areas in the cold northern regions of Canada, Russia and Sweden have been converted into productive farm-lands by breeding new crop varieties to suit them and one is tempted to hope that the plant-breeder, with

the help of the plant physiologist, may also be able to turn some of the great semi-arid areas of our tropical colonies into productive farm lands, by breeding suitable drought-resistant crops, thus relieving the pressure on the land in the areas of higher rainfall.

Apart from breeding for drought-resistance, there is a need for new cereal varieties which are resistant to striga, or witch-weed, a major pest in some areas.

The impact of our civilization on the tropics has had some unexpected results; one example being the great increase in bird-damage to grain crops now that so many native children go to school and so are no longer available for bird-scaring. Because of this new situation there is an urgent need for the plant-breeder to produce bird-proof varieties of millet and other grain crops.

Apart from the need for improving the staple grain crops, it is highly desirable that large-scale breeding work should be carried out with the pulse crops, including the soya bean, a plant which although not of tropical origin, has proved itself adaptable to a wide range of conditions. It is not to be expected that ready-made soya varieties suitable for our tropical dependencies will be found, but it should be possible to breed varieties suited to the conditions found at medium and high elevations in the tropics. Some agriculturalists argue that it is pointless to worry with the soya bean in the tropics when one has an admirable crop like the ground-nut already established there. There is a lot to be said for this view, and there is always the assumption that a long-established, or indigenous, plant will respond better to development than a new introduction, but the peculiar merits of the soya bean and the enormous range of its food products—which include a very useful milk substitute—make it very desirable that its possibilities should be fully investigated in our tropical dependencies.

Another plant awaiting the attention of the plant-breeder in the tropics is the so-called Irish potato, a crop which until the sudden appearance of Late Blight in Kenya in 1941, was well on its way to becoming a major food crop amongst the natives living in the East African highlands. The new knowledge of potato breeding in Britain, following on the discovery of new breeding material in South America, holds out the hope that blight-proof potato varieties can be bred to replace the susceptible varieties of the past, the loss of which was a serious blow to the native farmer.

While on the subject of root crops, I should like to say a word in defence of cassava which was scornfully referred to at the Hot Springs Conference as a lazy man's crop. While admitting its imperfections as a staple food, the value of cassava as a main source of starch for many thousands of Africans cannot be doubted. Apart from its hardiness and the ease with which it can be grown, cassava has the added advantage of being notably resistant to drought and locusts, while the fact that its roots can be left in the ground unharvested for long periods makes it a valuable food reserve and a protection against famine.

All nutrition workers would, I think, agree that there is need for introducing cultivated green vegetables into the native diet in most of our colonies. Almost all African tribes collect and use wild plants as vegetables, but in tropical Africa as a whole one does not find any cultivated vegetables to correspond with the cruciferous vegetables which form so important a part of the supplementary diet of European and Asiatic peoples. Africans, it is true, are beginning to appreciate some of our European vegetables—an appreciation which sometimes manifests itself in the form of extensive praedial larceny—but our so-called European vegetables usually thrive only in the cooler parts of the tropics, and there is a need for carrying out breeding and selection amongst the better-known wild spinach plants of the tropical lowlands, such as the edible Amarantus and Besella species.

In conclusion, we are faced to-day with the gigantic problem of how to provide a better standard of nutrition for the vast and varied population of our colonial dependencies where, in some regions, we are up against the spectre of an increasing population accompanied by a decreasing soil fertility brought about by soil erosion and other causes. In order to help solve this frightening problem, we should put the improvement of food plants by plant-breeding in the forefront of our policy, and set up special plant-breeding stations where necessary solely for native food crops. The plant-breeder, in collaboration with the agricultural officer and nutrition worker, can play a major part in helping to solve the nutrition problem by breeding more productive food plants for direct or indirect consumption by man. At present the science of plant-breeding is not being made full use of in our colonies, nor can it be made full use of until the number of plant-breeders trained in Great Britain and the Commonwealth is increased very considerably.

NOTES ON THE HIDES AND SKINS INDUSTRY

By M. H. French, M.A., Ph.D., A.R.I.C., Dip. Agric. (Cantab.), Veterinary Laboratory, Mpwapwa, Tanaganyika Territory

PART III

Factors Affecting Quality

Histological studies have shown that hides and skins are composed of three layers, each with a distinctive structure, namely, a thin outer layer known as the epidermis, a thick central layer called the dermis and a relatively thin inner layer referred to in the trade as the "flesh" (connective tissue, fat and muscle). In tannery operations the hair, the outer epidermis and the inner fleshy layers are removed before the central dermis is converted into leather and the type of leather that can be made is largely governed by the physical structure of the dermis. The dermis can be easily differentiated into two layers, an outer layer containing many cellular organs and the hair follicles which forms the grain of the leather, and an inner layer of interwoven fibre bundles known as the corium. The structural details of the grain layer exert a considerable influence on the aesthethic value of leather. The fineness and compactness of its fibrils affect the smoothness of the grain surface, the degree of glandular development influences the tightness of the grain, whilst the arrangement of the hair follicles and their size impart a pattern to the grain which is characteristic for each animal species though small variations occur (*a*) between different parts of the same animal and (*b*) with age. On the other hand, the anatomical features of the corium largely determine many of the utilitarian properties of leather such as resistance to abrasion and tensile strength. The tightness of packing and the size of the fibre bundles, their degree of interweaving and their angle of weave are characteristics of the corium structure, which vary (*a*) between different species (*b*) sometimes even between different breeds of the same species and (*c*) between different parts of the same animal, and which affect considerably the physical properties of leather, though the latter can be modified to suit a wider variety of purposes by tannery operations. [5] [6] [7]

The relative thickness of the grain and corium layers varies from species to species and also between young and mature animals. The grain layer is very much more uniform in thickness than the corium so that it forms a greater proportion of the total thickness in skins from small or young animals than in skins from large or older animals. Because wear and strength are determined more by the corium than by the grain layer, thin skins are, per unit of cross section, weaker than thick ones and this has a considerable bearing on the uses to which they can be put. It is by no means true, however, that because leather from calf, goat and sheep skins wears less well and breaks more easily than leather from steer hides the former will be worth less; they are used for entirely different purposes and their relative values vary with fluctuations in world supplies and the vagaries of fashion.

Variations between different parts of the same hide or skin

When it is remembered that the hide or skin covering certain parts of the body, such as the flanks, is subjected to considerably more flexing than that over the back, it is not surprising to find that hides and skins are not uniform over their entire area in thickness, compactness of fibre structure and the extent to which the fibre bundles are interwoven. Wilson [5] has shown that in calf-skin, the grain layer is nearly uniform in thickness over the whole surface but that the corium thickness varies considerably between the different parts. In the butt area (back, rump and part of sides) the corium is nearly three times as thick as in the shanks and the fibre bundles are more intricately interwoven. The corium over the shoulder is thinner than over the butt area and the fibres are finer. In the belly the fibres run nearly parallel to the surface and give rise to a spongy leather with considerably less resistance to abrasion than the firm, solid leather from the butt. It is for this reason that, in flaying animals, the butt area should be left intact and the belly area cut open and, when branding animals, the brand should not be placed on the butt area.

Variations due to Sex

Cattle hides are often referred to in the trade as bull, steer, stag and cow hides and in some countries are so separated because the sex of animals is reflected in the nature of their hides or skins and this affects the quality of the leathers which can be produced. "Bull" hides are from animals that have not been castrated

and have heavy, thick necks and shoulders but thinner butts than steers. The substance is loose and the final leather is more spongy and less valuable than that from steer or cow hides. "Steer" hides are from animals castrated before puberty and are much more uniform in thickness and structure than bull or cow hides. The fibres are plumper and more densely packed so that generally speaking the best sole bends are produced from steer hides. "Stag" hides are from animals castrated after puberty and vary considerably in structure according to whether castration occurred late in life or soon after puberty. In the former case the hides resemble bull hides whilst in the latter case they approximate more closely to steer hides.

Hides from females are lighter in weight than those from males and usually possess a finer grain. Skins from female calves produce superior leather to that from male calves and this difference persists throughout life except when males are castrated. Castration causes male hides to become superior to cow hides. Hides from virgin heifers are superior to those from cows and one of the effects of repeated pregnancies and lactations is the development of a looser fibre structure so that the resulting leather is more spongy. Further deterioration in hide quality from repeated breeding is the formation of patches of raised or depressed grain, referred to in the trade as "old grain," and a tendency for the hides to become thinner over the shoulder, rump, flank and belly. Hides from cows that have had many calves often show a defect, known as "hippiness." This is caused by the hide being moulded over the fully matured hips so that, when the hide is spread out, bulges appear which prevent it from lying flat and detract from the smooth appearance of the final leather.

In sheep and goats the main sex differences are the greater weight and coarser grain of skins from male animals and, in goats, the more pronounced odour of male stock.

Variations due to age

One of the main differences between leathers made from young and old animals is the appearance and fineness of the grain. Generally, the younger the animal the finer the grain because not only is the pattern of the hair follicles, characteristic for any given species, laid down before birth but so also is the total number of follicles. As an animal increases in size with age few if any new follicles develop, so that the distance between adjacent follicles increases in proportion.

As has already been indicated, the grain layer forms a greater proportion of the total thickness in skins from young animals because as an animal grows with age the increase in thickness of its hide or skin is due chiefly to development of the corium thickness. Since it is the corium which is mainly responsible for the tensile strength of leather an important difference between leathers from young and old animals is the smaller tensile strength and resistance to abrasion of leathers from immature animals. Further, in skins from immature animals the fibres are more tender and break more easily than the fibres in hides from mature stock so that, although immature animals yield leather with fine compact and tight grain, the latter has less resistance to scuffing than the grain from mature animals. This combination of greater proportion of grain, finer grain appearance and lower tensile strength and resistance to abrasion and scuffing in leather from ammature stock has resulted in a demand for these leathers for such purposes as shoe uppers, fancy bags and gloving leathers, where fineness of appearance and ability to retain embossed patterns are the most important factors. This fact, whilst it allows immature skins to be bought for higher prices in relation to the value of mature hides and skins than would otherwise be the case, makes their market price more liable to fluctuations as a result of changes in prevailing fashions.

Hides and skins from very old animals are less valuable than from those in the prime of life because they are more likely to suffer from defects due to disease and mechanical injury and also because they do not tan so well. Their substance is very uneven and leather made from them is not so resistant to the penetration of moisture.

At the other extreme are skins from unborn and still-born animals and from animals dying or slaughtered soon after birth. These skins are far more common than is generally supposed but very few are prepared for the market in East Africa. In the aggregate the hide and skins industry loses a substantial sum of money annually from the wastage of these skins though the individual skin may be worth little. Such skins differ from other immature skins in being extremely thin, light in weight, containing a high proportion of grain layer and in possessing a very weak fibrous structure. Such foetal skins are very rarely smooth, so that leather made from them is crinkly as well as thin. Such leathers are used only for special purposes such as gloves, fancy leather articles,

linings and facings, etc. Also, because of the soft wavy or patterned hair or wool on such foetal skins, they are often tanned with the hair or wool left on and they then command special prices for bags and wearing apparel.

Variations due to feeding and starvation

The effect of the nutritional plane on the value of hides and skins has not been adequately worked out but, in general, hides and skins from well-fed animals are plumper, thicker and of better substance than from animals in poor condition. Starvation or emaciation as the result of disease causes hides and skins to become thinner, lighter and less valuable for leather. Excessive fattening is never undertaken in East Africa but certain breeds of sheep deposit excessive quantities of subcutaneous fat and this is reflected in a greater proportion of fat to collagen in their skins. Since tannery operations remove excess fat, skins from very fat sheep yield more spongy leathers than skins taken off in the dry season when fatty deposits are less prominent.

Variations due to season

During the winter in temperate latitudes, animals grow longer hair or wool than in the summer, and this not only reduces the proportion of leather-forming substance in the total weights of hides and skins but causes their substance to be less dense and of lower value for leather. There is of course less variation in the quality of hides and skins due to seasonal take-off in East Africa than in the more temperate regions of the world but even so, at the higher altitudes, some seasonal variations of the above nature are to be expected. Another seasonal difference in quality is to be expected in the skins taken from young calves (a few months old) born in the hot season and particularly in calves from European or high-grade animals. Calves born in hot regions show a greatly increased circulatory rate and dilate their skin vascular systems to a maximum in an effort to dissipate heat. This means that, when only a few months old, their skin blood-vessels tend to be more highly developed if they are born in the hot season than if born in cold periods. This may cause the final leather from such young animals to have a more "grainy" surface and pre-disposes to bacterial action resulting in "veiny" leather. This difference due to season disappears to a large extent if the animals do not die or are not killed till they are older.

Variations due to species and breed

Cattle hides and calf skins have similar structures though age affects the proportions of corium to grain. The fibre bundles in cattle corium are plump, well-filled and except in the belly and flank areas intimately interwoven. The result is that cattle hides produce leathers of high tensile strength and great resistance to abrasion. Zebu and European cattle give hides of different quality, the former being smaller, thinner and lighter than the latter. Even in European cattle differences in hide quality occur between breeds. Dairy animals such as the Friesian give hides of more uneven thickness and less dense fibre structure than dual-purpose cattle such as Red Polls or beefy types like the Sussex [8]. Within Zebu cattle there are probably types which give better hides than others but this is a problem for future animal husbandry research to decide. European cattle have no hump and a premium is paid by tanners for humpless hides.

Both woolled and hair sheep skins are produced in East Africa and the skins from the two types differ in certain important details. Sheep skins from woolled breeds have a very different structure from cattle hides. The grain layer of course forms a higher percentage of the total thickness but there are very many more glands in the grain layer of sheep than in that of cattle. So crowded are the glands, in fact, that the wool follicles are distorted and curved. The collagen fibre bundles are not so compact nor so closely packed in sheep as in cattle and the fibres are less intricately interwoven but run more nearly parallel to the grain surface. The proportion of adipose tissue to collagen varies considerably with feeding and an almost continuous layer of fat may be formed between the grain and corium layers. As the fat is removed in the tannery, woolled sheep skins often give leather with a loose or even a separated grain. Also, since the glandular tissues are broken down in the beam-house, woolled sheep grain is very open and spongy. This looseness of grain with a very open corium structure puts woolled sheep leathers in a class by themselves for use as garments and linings. Woolled sheep, owing to the retarded drying of the epidermal surface by the thick layer of damp wool, often show large areas of grain putrefaction.

Hair sheep on the other hand, have a less crowded glandular area in the grain layer so that the hair follicles are straight and the grain of leather made from them is less spongy than

the grain in woolled sheep leathers. The deposition of fat is, however, just as likely to occur in a continuous layer between grain and corium as in woolled sheep, so that loose or separated grains are encountered in the leather. The grain is tighter and finer than in woolled types but the corium structure is still open.

Goat-skins are intermediate between haired-sheep and calf-skins. The grain layer is less glandular than sheep, and so the grain of the leather is firmer and does not separate because of a fatty layer between the grain and corium. The fibres of the corium are fuller and more interwoven than in sheep and give a firmer leather structure. The appearance and coarseness of the grain of goat leathers varies with skins from different districts and different breeds and some East African goat-skins yield both excellent grain and good substance in leathers made from them. Again it is probable that the researches of the animal-husbandry worker on this subject would prove of great economic value to the industry.

Miscellaneous factors affecting quality

Size.—The size of hides or skins of itself affects quality in the various ways described above but size is a basic factor which may affect price. When a piece of leather is to be converted into the various articles of commerce it has to be cut into varying arbitrary shapes and there is always a certain amount of waste attached to cutting. The amount wasted is higher in small than in large hides or skins and the cutting value is taken into account by tanners purchasing raw stock.

Colour.—The colour of the hair on cattle hides, goat and haired sheep skins does not affect their quality for market value but in woolled sheep, black- or grey-woolled skins realize lower prices than white ones. The reason is not that the leather value is any lower than in white-woolled skins but because the coloured wools fetch lower prices.

It is true that certain origins of goat-skins, such as the "Red" Sokotos and "White" Bornus of Nigeria, include a colour in their specifications, but the difference in prices for these origins is not because of their particular colours. "Red" Sokoto skins command a high price because the Sokoto breed of goats has secured a trade reputation for the excellent quality of its skins. It so happens that this breed has a genetical factor in its make-up which gives it a red colour and the appearance of other colours is taken as evidence of cross-breeding with other breeds. The red colour is purely fortuitous and the good quality of Sokoto skins is due to the presence of other hereditary factors. So long as these other characters, responsible for skin quality, remain unimpaired the colour would not really matter and the trade only stipulates red colour in these skins because, by a lucky chance, it is an indication of the genetical purity of the Sokoto goats from which they were taken.

Growth of wool or hair.—There is as yet no scientific correlation between the growth and nature of the protective covering (hair or wool) of hides and skins and the leather-producing value of their corium, but apparently there is some inter-relationship. As the hair becomes longer the corium structure becomes looser and though this factor is recognized and allowed for in the prices paid for winter and summer hides of temperate areas it has less significance in East Africa. In the case of woolled sheep, however, the effect of heavy wool growth is more obviously related to the looseness of the corium structure no matter how equitable the climate. Shearing, by stimulating wool growth, causes still further deterioration of skin quality and the extent of the deterioration increases with the number of shearings.

Plump hides are of greater value for sole leather production than thin hides. Plumpness is really a measure of the amount and compactness of the hide substance so that plump hides have a high weight/area ratio, but a high value for this ratio alone does not constitute plumpness. Old bulls, for instance, have thick heavy hides, tough in fibre but loose in structure and are therefore not plump. Plumpness combines all the factors of thickness, close packing of fibres, strong fibres and intricate interweaving of the fibre bundles.

Spready hides are those that are wide and of large surface area in proportion to their weight. Such hides are commonly produced by cows that have had a number of calves and leathers from such hides are sought after for upholstery purposes.

Grading of Hides and Skins

In the earlier parts of this article the factors affecting quality have been stressed because obviously a Grade I article will command a higher price than a Grade IV but, as shown in the above sections, grade alone does not fix the price which can be paid to exporters under conditions of open world competition. One tanner is willing to pay more for heavy plump hides because he makes only sole leathers,

another is prepared to pay more for calf-skins because he specializes in high-grade upper and fancy leathers whilst a third will purpose only those origins which he knows will yield a high percentage of spready hides suitable for his upholstery leather trade. Thus the exporters have to prepare selections which suit their buyers or find buyers willing to purchase their selections and only by knowing the world markets can the best prices be realized. According to the success of the exporters in correctly placing their hides and skins, so does the level of prices vary to producers. The end-uses for which the leathers will be employed may cause small modifications to the general system of payment according to quality, in the same way as a world shortage of a certain type of leather will place a premium on hides or skins suitable for its manufacture, or a change of fashion in leather goods will alter the demand for other types of hides or skins.

These price factors are usually small in proportion to the difference in values between Grade I and Grade II hides or skins but they indicate how difficult it is to fix absolute producer prices. A further difficulty in this connexion is that quality grading of air-dried hides and skins is a more complicated business than the grading of maize or groundnuts. Hides and skins are graded largely on appearance but, as indicated in earlier parts of this article, there are many invisible defects and so the experience of a grader and his knowledge of the different origins become important factors. Not only is the normal human factor introduced whereby one grader will say a given hide is Grade II whilst an equally experienced grader will say it is a Grade III, but the extent of possible invisible putrefactive damage has to be assessed. By knowing the production methods of given districts and the past results of these different origins in tanneries, exporters can relax or stiffen their grading standards according to the district involved and thereby prepare selections which maintain a certain standard of quality in their export parcels.

It is not possible, in our present state of knowledge, to prepare a schedule from which the grade of hides and skins can be determined automatically. When hides, such as the frigorifico hides from South American packing houses, are all of the same origin, feeding and preparation, it is possible to achieve a fair measure of success by grading on appearance only, but, when the methods of preparation vary appreciably and the opportunities for invisible putrefactive damage to occur are as common as they are in East Africa, it would be a bold person who claimed that exact grading could be based on appearance alone.

Generally speaking, grading takes into account the following factors: freedom from cuts, gouges, holes, sores, scars, brand marks and hair-slip, the standard of preparation, freedom from excessive deposits of meat and fat, absence of disease marks, distortion, putrefactive smells and damage by water, smoke, insects or vermin; allowance is also made for the trim, pattern and general condition of the hides and skins and the possibility of invisible putrefactive damage. The extent of any defects affects the degree of down-grading. Factors such as size, weight, suitability for certain leathers, etc., assume more importance when the exporters make up their export selections.

When marketing hides and skins they are also classified into sun and shade (or suspension-dried) classes and the former is always paid for at a lower rate than the latter. In East Africa hides should be bought by weight as well as by grade, but sheep and goat skins are purchased by the piece and grade. A distinction is also made between "humped" and "humpless" hides and the latter always command a higher rate than "humped" hides.

In East Africa many producers live long distances from the exporters' buying establishments and there is often a chain of two, three or four middlemen dealers, through whose hands hides and skins pass before reaching the exporters. The greater the number of middlemen taking profits from the collecting side of the industry the lower will be the prices to producers. If to this chain of middlemen buyers is added the iniquitous system of shella-bella buying, i.e. buying at a flat rate irrespective of quality and weight, it is easy to see that producers can receive but a fraction of the export value of their produce. Unfortunately this shella-bella buying is far too common and efforts must be made to stamp it out because, unless producers receive payment according to the quality of their produce, it is difficult to imagine any general quality improvement in the industry.

SUMMARY

1. There is much wastage of valuable raw material because many sheep and goat skins are not prepared for the market and many calf, kid, and lamb skins are not preserved.

2. There is a further loss to the industry through failure to prepare and dry the small skins from still-born calves and those taken

from females which died or were slaughtered in the late stages of pregnancy. The individual value of these skins will be little but in the aggregate they would bring in a larger sum than is commonly supposed.

3. The evils of branding have been stressed but the high percentage of branded hides being marketed indicates that much remains to be done to eliminate this serious defect. Brands should never be large nor deep and should be placed on the least valuable portions of the hide.

4. All surplus males should be castrated at an early age and thereby decrease the proportions of the lower-quality "bull" hides and skins.

5. The keeping of female stock long after they have passed their peak of efficiency should be discouraged as hides and skins from such aged animals reduce the average quality standard and the reputation of East African origins.

6. The slaughtering of prime stock before the dry season is too advanced would allow heavier and better hides and skins to be marketed as well as leaving more food for the remaining stock. The provision of dry-season reserves of food and water would help to reduce the annual loss to the industry caused by the thin, light hides and skins from starved animals.

7. Many animal-husbandry factors, the solution of which influence the revenue from the hide and skins industry, have not yet been worked out. For instance, goats from certain districts yield better skins than those from other districts and it is of economic importance to know how far the differences are due to genetical, nutritional and climatic factors. Similar results of economic importance could also be obtained from studies on cattle and sheep and the practical application of the results obtained could have far-reaching influences on future animal-husbandry developments.

8. The following defects should be avoided and can be avoided if reasonable attention is paid to the matter: Mechanical and branding damage to the hides and skins of living animals, bruising, dragging of carcasses and dried hides and skins over sharp edges, bad flaying, cuts, holes and gouge marks, sun-drying, delay in washing, cleaning and drying, and storage under improper conditions. Attention to these factors alone would effect a tremendous improvement in the trade reputation and increase the revenue out of all proportion to the cost of the effort required.

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CORRESPONDENCE

University of the Witwatersrand,
Johannesburg, South Africa,
9*th June*, 1946.

The Editor, East African Agricultural Journal

SIR,

Having read a letter in the April issue of the *East African Agricultural Journal* about compost-making I would like to bring to your notice a cheap and simple method which has been proved successful in South Africa.

The process is centred round the *boma*. Any trash or crop residue is put into the *boma* and left to be well trampled and manured by cattle, pigs and poultry. This trash, while also serving as bedding is left in the *boma* for about six weeks, until it is well broken down. Of course the length of the period will depend on the number of cattle available.

At the end of this period the residue is collected and stacked in long heaps four to five feet wide and three to four feet high, near the *boma*, and preferably in the shade. It is left until the heat due to fermentation has cooled, which takes about three weeks. The internal temperature may easily be determined by inserting a piece of wire and leaving it for a few moments, if the wire is hot then the stack is not ready. When it has cooled it is turned over, watered, and then re-stacked and allowed to cool again. The mixture should then have a soil-like texture. At this stage it is ready. It is advisable to spread it on the land immediately and harrow it in at once with a disc harrow, but if it is not immediately required it may be re-stacked and covered over with some suitable material to prevent drying by the sun.

If required, lime and other artificial fertilizers may be mixed with the compost, the best time to add these is while the trash is in the *boma*; this ensures that it will be well mixed with the trash.

Yours, etc.,
V. R. S. BECKLEY.

THE CHEMICAL CONTROL OF PESTS*

Man, like the rest of living creation, is engaged in a never-ending struggle for the necessities of life. There is competition from all directions. Many kinds of bacteria, for instance, while individually insignificant, can kill him by sheer weight of numbers. The crops upon which he depends for sustenance are open to attack by hosts of competing organisms; they may be destroyed by disease or smothered by the rank growth of weeds. Countless varieties of insects are inimical to human life and welfare. Some, like locusts and termites, devour foodstuffs or damage property; others, such as mosquitoes and lice, are dangerous as disease carriers. Rats and mice and other vermin take serious toll in similar ways, and the age-old problem of the control of pests is still but partially solved.

The advance of chemistry has given new power to one of the oldest weapons in man's armament of self-protection, namely the use of poisons. The elaboration and application of poisonous substances dates from the earliest times. Those known to the ancients were primarily of natural origin, and included compounds of lead and arsenic, snake venoms, and extracts of certain plants, such as hemlock. We know, too, from the Homeric writings, that the Greeks used sulphur dioxide as a fumigant.

This list comprises many powerful poisons, but their practical use was, and is, limited inasmuch as their action is indiscriminate. They are as deadly to man as to his intended victims —sometimes more so—and their application is therefore attended by considerable difficulty and danger. A great stride forward was taken in the nineteenth century, with the discovery of poisons that are specific in their action. Ehrlich, the pioneer in this work, was able to show that certain arsenical compounds will destroy bacteria in the human body without at the same time doing irreparable damage to the tissues of the patient. There have been few more momentous discoveries, though, as has often happened in similar cases, subsequent progress was not at first rapid. Thousands of further poisons, including dyes, were investigated, but for many years the only other outstanding achievement to note was the discovery of a compound possessing specific action against the trypanosomes of malaria. Within the last decade, however, the chemical control of bacterial pests has been astonishingly strengthened, first by the discovery of the sulphonamide drugs—efficient specifics against staphylococci and streptococci—and more recently by the discovery of penicillin, a substance so highly specific against certain bacteria that the risk of giving a patient an overdose is negligible.

These discoveries were important not only because of their immediate application, but because they proved beyond the possibility of doubt that the search for specific poisons offered every prospect of reward. They thus opened up a new field of chemical activity—a field that is already bearing fruitful crops. A feature of much interest is that specific poisons have now been found for certain plants, and have already been applied in agriculture for the destruction of weeds. The original observation was that a number of growth-promoting compounds, chemically allied to alpha-naphthy-acetic acid, have a powerful effect in the contrary sense when applied at greater concentrations. One of these substances, "methoxone", has now been developed commercially, and has proved of very considerable value in freeing cereal crops—which are almost unaffected by it—from harmful weeds such as charlock.

The pyrethrums and derris are examples of natural poisons with a specific action against insects. To them have been added during the past few years the synthetic substances "D.D.T." (dichloro-diphenyl-trichloroethane) and "gammexane", the gamma-isomer of benzene hexachloride.

These substances, although not very toxic to animals and almost without effect upon the leaves of plants, are among the most powerful insecticides known.

The majority of the specific poisons hitherto investigated were discovered either by chance or by the laborious examination of thousands of different compounds in the hope that, sooner or later, useful ones would be found among them. An urgent need for the speedy development of this important branch of applied chemistry is a more logical method of search; and as this can come only from an understanding of the mechanism of specific toxicity it is satisfactory to know that a beginning has been made in this direction. There is indeed evidence that at least some specific poisons act in virtue of their chemical resemblance to substances which play essential parts in metabolism. One such substance is *p*-aminobenzoic acid, to

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which the sulphonamides have a general similarity of structure; and Fildes and Woods have suggested that the toxic action of the sulphonamides may be explained on the assumption that their molecular architecture enables them, so to speak, to act as faulty keys that enter, but jam, locks properly turned by *p*-aminobenzoic acid. By replacing this acid in a cell reaction, they distort or stop the normal course of the metabolism. Similarly, it has been suggested that the toxic action of gammexane is attributable to its structural resemblance to the natural form of inositol. These hypotheses are still highly speculative, but they form a point of attack and may lead to a gradually increasing comprehension of the mode, or modes, of action of specific toxicity.

Whether progress be rapid or slow, the discovery of specific poisons makes it clear that we approach an age in which the destruction or control of pests by chemical means will become more and more practicable. At first sight, the prospect would appear wholly delectable; fields and gardens without granaries and warehouses without rodents, each bacterial disease with its appropriate chemical antidote. Caution, however, bids us pay attention to the fact that dangers may lie ahead. Man occupies a place in a complex system of interacting organisms, among which a state approximating to dynamic equilibrium exists. He now possesses the means of radically altering several of the factors in this system, and is naturally tempted to employ them at once to what he believes will be his advantage. Yet while the immediate effects of such control may be favourable, human foresight is still too limited for us to be certain that the ultimate effects will continue to be favourable. On the contrary, it is easily conceivable that destruction of one pest may promote the increase of another upon which it normally preys; for, as Augustus de Morgan wrote: "Great fleas have little fleas upon their backs to bite 'em, and little fleas have lesser fleas, and so *ad infinitum*".

Interference with the balance of nature must be attended by more or less risk, and it does not require a very vivid imagination to picture the consequences of, say, the destruction of the nitrifying bacteria of the soil. Such a complete disaster may be unlikely, but minor ones of the same kind could be sufficiently disturbing, and their possibility could not be ruled out if chemical control of pests were applied without due discretion and preliminary investigation.

These general conclusions are of course obvious upon reflection; unfortunately there is little evidence that they are receiving serious study. It seems not improbable that future use of selective poisons may do more to change the face of living nature than any previous application of scientific knowledge; it would be a tragedy if, through premature or ill-considered action, discoveries which have immense power for good should be so mishandled as to occasion misfortune and evil.

PRELIMINARY TRIALS ON THE ROOTING OF CLOVE CUTTINGS

By L. M. Fernie, Superintendent of Plantations, East African Agricultural Research Institute

The clove is a notoriously difficult subject to propagate vegetatively. Grafting, with varying degrees of success, is reported from Amani, Orissa, and Zanzibar; Ridley (1912) states that it can be propagated by layers; the only report of the successful rooting of cuttings comes from the Royal Botanic Gardens, Kew (1938) (Feilden and Garner, 1940).

In September, 1945, preliminary trials with cuttings were laid down in the propagating frames at Amani as follows:—

(1) Softwood leafy terminal cuttings: clean cut at base.
(2) Softwood leafy terminal cuttings: taken with a "heel".
(3) Semi-hardwood leafy terminal cuttings: clean cut at base.
(4) Semi-hardwood leafy terminal cuttings: taken with a "heel".
(5) Hardwood leafy non-terminal cuttings: clean cut at base.
(6) Hardwood leafy non-terminal cuttings: taken with a base.
(7) Hardwood leafless non-terminal cuttings: clean cut at base.
(8) Hardwood leafless non-terminal cuttings: taken with a "heel".

The cuttings were planted in a rooting medium of washed river sand in two separate frames. Frame No. 1 was provided with bottom heat in the form of fermenting cow manure to a depth of 12 in.; this was the base on which the sand was spread to a depth of 4 in. Frame No. 2 had no bottom heat, the

available space being occupied entirely by drainage stones which formed the base for the rooting medium.

All the hardwood leafless cuttings (treatments 7 and 8) soon rotted and died. Similarly, cuttings of all types which failed to retain their leaves, died as soon as the leaves were lost.

Cuttings which showed most promise of success were softwood leafy terminal cuttings taken with a "heel" (treatment 2). This confirms results obtained at Kew. The first rooted cutting was found in the medium with bottom heat, twelve weeks after setting. A good large root was formed, but unfortunately it was broken in the excitement of discovery. This cutting was replanted but the remaining stump of the root subsequently rotted. A small percentage of other cuttings of this type commenced to form roots, 16 weeks after setting, in media both with and without bottom heat. In each case roots formed towards the extremity of the upper side of the "heel".

Conclusions

Softwood leafy cuttings, especially those taken with a "heel", show most promise of success. The use of glazed propagating frames, where a high humidity can be maintained and adequate light admitted, is essential when using this type of material.

As with many plants, success is dependent on the retention of a proportionate healthy leaf area.

Further trials with softwood leafy cuttings, some with a "heel" and some with a clean cut at the base, have been laid down to test the effects of different rooting media.

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EFFECTS OF ANTI-MALARIAL D.D.T. SPRAYING ON CROPS AT TABORA, TANGANYIKA TERRITORY

The following observations on the effects of D.D.T. on crops were made during a trial of spraying from the air which took place at Tabora between 20th December, 1945, and 14th March, 1946. The D.D.T. was sprayed as a solution in gas oil and furnace oil.

The weather was dry for the time of year, and the table gives a summary of the rainfall during the period:—

Month	Total number of days	Number of days in which rain fell	Rainfall	Highest individual fall recorded
			(*inches*)	(*inches*)
December ..	12	4	1·21	0·54
January ..	31	15	4·88	1·90
Febuary ..	28	10	3·28	0·86
March ..	14	6	1·86	0·82

The dry weather reduced the amount of D.D.T. required for mosquito control, and thus the vegetation did not receive so much as it might have done in a wetter season.

Five long narrow strips of land in the low-lying seepage-water areas near Tabora were sprayed separately. These were about a mile wide, and were carrying maize, cassava, ground-nuts, beans, paddy, and small groups of mango trees. There were stretches of pasture grass and grass fallows, and the uncultivated parts of the drier lands were under secondary scrub bush. During the period of observation the crops were in all stages of growth from germination to flowering and maturity.

The effect of spraying was to damage the leaves, especially broad-leaved plants, resulting in numerous spots and holes. This was caused by the heavy oil, and the D.D.T. itself did not seem to have any effect on foliage. Less damage was seen on the leaves of ground-nut plants, and there was only slight damage to paddy and grasses. Full grown leaves of maize plants were badly affected, but this did not hinder the formation of cobs. On maize leaves and grasses the spray caused a streaky pattern instead of the spots and holes which appeared on the broad-leaved plants.

All vigorous plants were able to outgrow the damage without any effect on the crop, but the secondary scrub bushes were slower in outgrowing the spotting than were the cultivated crops. Flowers of crops and trees were only slightly damaged by the spray.

In this district young leaves of cassava and cowpeas are boiled and eaten, but the natives refrained from picking the leaves while spraying was being carried out, and no cases of illness were reported.

A. PITCAIRN.